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CR-149152

THIRD QUARTERLY REPORT

LANDSAT II INVESTIGATION PROGRAMME

No. 28230

REPORT NO. 553

SEPTEMBER 1976

(E77-10040) DEVELOPMENT OF REMOTE SENSING
TECHNOLOGY IN NEW ZEALAND, PART 1.
SEISMOTECTONIC, STRUCTURAL, VOLCANOLOGIC AND
GEOMORPHIC STUDY OF NEW ZEALAND, PART 2.
(Department of Scientific and Industrial

N77-11500

HC A06
MF A01

Unclass

G3/43 00040

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**ORIGINAL CONTAINS
COLOR ILLUSTRATIONS**

FOREWORD

This Third Quarterly Report is two or three weeks late. This delay, agreed to by Dr Robert Price of NASA, was to enable results of joint research by Dr M.J. Duggin of CSIRO (Australia) and by Dr P.J. Ellis of DSIR (New Zealand) to be presented in this report. Unfortunately, Dr Ellis had to leave New Zealand suddenly for a few weeks because of a family bereavement in England and, in this event, the material for which the report was delayed could not be included. It will be presented in the next Quarterly Report.

Dr Ellis will, however, have the opportunity of spending a short time at Goddard and at Sioux Falls on his way back to New Zealand. He will thus have the opportunity of presenting some of his work, and that of the other Co-investigators, at a meeting of Principal Investigators at Goddard.

In addition to the summaries of the work of the Co-investigators, this report contains material from a number of other investigators. This material illustrates the growing interest in the use of LANDSAT imagery for the solution of a wide range of problems in this country. For example, the forestry programme (Co-investigator Mr M.G. McGreevy) is being extended by other Forest Service staff (Mr N. Ching, Mr R. Dale and Mr R. Hodder). Again, the mapping and land use programme (Co-investigator Mr Ian F. Stirling) is being extended by Professor C. Ross Cochrane of the University of Auckland, and five of his students (G.H. Campbell, J. Batty, R.M. Bellingham, A. Male, and Caroline J. Strachan). The staff of Mr Stirling's Department are continuing to make excellent use of the material as will be evident from their report.

Our own staff at the Physics and Engineering Laboratory have been stretched to the limit by the needs of our own research programme, plus the need to service an ever widening group of other investigators with imagery, with facilities, and with advice. Dr Ellis and his team are to be congratulated on the remarkably fine job they have done in servicing so many users; and I would like to record our thanks for a job well done. In addition to their other work they have also organised a "Statement of Interest" from New Zealand users for participation in the LANDSAT C programme.

Again it is a pleasure to record my thanks to Dr Robert Price of NASA and to his colleagues, for assistance and co-operation both by way of the PEACESAT link and by correspondence.

Mervyn C. Probine
Principal Investigator

17 October 1976

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PART I

DEVELOPMENT OF REMOTE SENSING TECHNOLOGY IN NEW ZEALAND

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Remote Sensing Section Report No.: - RS 76/10

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1. INTRODUCTION

The first quarterly report under the LANDSAT 2 programme number 28230 was directed at outlining the functions of our group at PEL and discussing some of the basic techniques and items of equipment pertinent to the programme. The second report described in greater detail techniques and methods of analysis that are proving to be useful to our Co-investigators and other user groups (e.g. production of colour composites, preparation of coded computer print outs, thematic mapping packages, etc.).

This third report concentrates more particularly on the analysis of the LANDSAT products by some of our user groups.

Our role over the last quarter has largely been to assist user groups in relating the objectives of their studies to the imagery, illustrating the potential and limitations of the imagery, training them in the use of the colour additive viewer and in densitometric techniques, and bringing to their notice areas where further data or interpretative material could enable greater use to be made of the imagery. In addition to assisting such groups in our laboratory, a number of demonstrative presentations have been given to senior staff of user groups and allied governmental agencies.

Further, during this reporting period a joint "Statement of Interest" in the LANDSAT C programme, representing thirteen user groups, has been prepared and forwarded to NASA. The idea of establishing a LANDSAT/SEASAT receiving station in New Zealand has been actively discussed and interest in the proposal is growing.

The term "Outreach" would largely typify the activities of this laboratory group over the past quarter. The results of this work will be seen more in future reports from user groups. Particularly significant has been the use of our equipment by Prof. G.R. Cochrane of the Geography Department of the University of Auckland. Prof. Cochrane has commenced the first undergraduate/graduate remote sensing course in New Zealand and the results of some initial analyses by his group using our facilities are included.

Another user group that has really started to use the imagery in an operational sense is the New Zealand Forest Service. Their research area is already covered by a recognised Co-investigator (through M.G. McGreevy) and the initial operational results of this extension are included here. The Department of Lands and Survey continues to broaden and deepen their use of the imagery. Close liaison helps us all in applying the imagery to common tasks in New Zealand. The above departments are all actively working on a land use assessment of the King Country region. This work, using LANDSAT imagery, is included within their reports.

During the past reporting period we have profited from a visit by Dr M.J. Duggin, Head of the Remote Sensing group at Mineral Research Laboratories, Commonwealth Scientific and Industrial Research Organisation (C.S.I.R.O.) in Sydney, Australia. This work on atmospheric transmittance with Dr F.J. Ellis (of PEL) is a continuing joint programme commenced in 1975. These trans-Tasman links will be of

great assistance to both groups. It was hoped to include a more detailed report on this work within this report than appears. Unfortunately during the final analysis and "write up" stages Dr P.J. Ellis, because of a family bereavement, had to make a visit to England, and this work will have to be largely deferred until the next quarterly report.

In August we were joined by Mr A.J. Lewis of the Department of Geography and Anthropology, Louisiana State University, U.S.A. for a nine month period of sabbatical leave. As noted earlier, this laboratory's activities in the field of data analysis and interpretation are becoming more intensively user oriented rather than "technique-proving". Dr Lewis' visit thus comes at a particularly worthwhile time for development of our programme. Already his comments have assisted a number of user groups, and his particular interest in resource mapping and geomorphology will add to our programmes.

2. TECHNIQUES

2.1 Photographic Processing

Ideally bulk production of colour prints would make use of "Master" colour negatives, which would allow prints at a variety of scales to be made with ease. If the original is poorly registered, however, enlargements will suffer from bad "colour fringing", making interpretation of smaller features particularly difficult.

Recent improvements in techniques have resulted in overall registration errors of less than 0.02 mm in the final 1:1,000,000 colour composite print.

Original transparencies obtained from the U.S.A. consist of sets of positives and negatives. The positives are of more variable quality than the negatives, particularly with regard to base fog density, and "flare" associated with regions of high contrast. For this reason it is desirable to use the negatives for both colour print and "master" negative production. During the last three month period 1:1,000,000 scale colour composite transparencies have been produced of the 22 Dec 75 Taupo/Hawkes Bay scene (Scene No. 2334-21123).

Figure 1 is such a transparency of the Taupo/Hawkes Bay region. A comparison with the colour composite print - included as Figure 3 in the Second Quarterly Report - demonstrates the improved intensity and target resolution attainable with the transparency product. Both transparency and print were produced from the same 70 mm negatives in the PEL colour additive viewer.

Two transparencies of this scene, having slightly different colour balances, have been provided to Department of Lands and Survey and are commented on in Part IV of this report.

A colour composite of the same scene has also been produced on Cibachrome transparency material. This was done using the 70 mm black and white negative transparencies in the colour additive viewer. This negative transparency has then been printed on to Kodak Ektacolour paper at a scale of 1:250,000. This has produced the best quality enlargements to date.

2.2 Products for User Groups

2.2.1 Photographic Products

Normally Co-investigators have their own sets of LANDSAT black and white imagery. Other user groups working on specific projects can be supplied with black and white enlargements etc.

Both groups are supplied by us with colour composite products, paper prints or positive transparencies as required.

Our standard product is a 1:1,000,000 colour composite print with MSS Bands 4, 5 and 7 printed through blue, green and red filters respectively. In general, we aim to reproduce the step wedge at the bottom of the image as a grey scale. However, to emphasise certain features on some scenes, or for particular users, we bias the print towards the green or blue to whatever gives a better result. In addition, we print combinations of negative and positive transparencies if these are necessary to bring out further detail (e.g. water features or geological detail).

2.2.2 Colour Isodensitometry

The colour isodensitometer enables a user to "break" a black and white transparency into some eight stable and repeatable density levels represented by different colours. ("Eight" is a practically determined figure, somewhat at variance with manufacturer's hopes!) Such hue coding of tonal variation, when combined with colour additive multi spectral imagery, can add to interpretations begun using such colour composited products. Commonly the colour television screen output device is photographed onto 35 mm colour slide material as follows:

- (i) photograph the initial black and white image on the monitor
- (ii) overlay a dot matrix (inbuilt machine function) or add a fiducial pattern to the original transparency and photograph the resultant image
- (iii) switch to the selected colour representation of the tonal differences and photograph the superimposed fiducial pattern in addition to the colour image
- (iv) photograph the colour coded image alone.

In this way tonal variations, represented by colours, may be

related to topographic detail when the slides are projected onto base map, or similar, material.

Examples of such colour coded isodensitometric work are given in Parts V and VI.

2.2.3 CCT Derived Products

Studies on the subtleties of canopy diseases in a forest, or sediment plumes in river/sea mixing, can often benefit from the use of a coded print out of radiance levels for that area, obtained from the CCT product, in addition to the colour composite or black and white imagery.

We now have 8 sets of Computer Compatible Tapes or CCTs. 128 x 128 pixel portions of these LANDSAT scenes of particular interest are being regularly supplied to user groups. In addition, two enhanced images have been prepared on the HP 2100 at PEL and written out on a "Photowrite" machine by Optronics International Inc. These two images of size 75 x 50 miles and 41 x 33 miles respectively both include the Kaingaroa State Forest area (see Figure 2) and are the best LANDSAT images we have produced so far. Black and white and colour prints of these scenes have been distributed to user groups.

2.3 Aircraft Programme

PEL has now obtained four seasons of coverage of the agricultural test site around Darfield. Computer analysis programmes are largely developed and have pointed out areas that need close attention, particularly in the realm of spectral signatures.

Stage two will involve detailed work on crop stresses, influences of: sun angle, grazing patterns, underlying soil types, etc., on the resultant signals we record. It will also include an attempt at typing crops outside our test area using the aircraft and satellite imagery.

Following discussions with the Ministry of Agriculture and Fisheries we plan to take a wheat inventory of a controlled section of the Canterbury Plains area during the coming summer. It is planned to underfly the predicted satellite overpasses once in October/November (1976) and again in January/February (1977) to gather data over the wheat maturation cycle. Ground truth, as above, for a small area will be obtained. For the larger controlled area more general ground truth will be gathered to confirm the analyses based on the aircraft and (hopefully) satellite imagery.

2.4 Collaboration with C.S.I.R.O.

Interchange of information on computer processing of CCT derived images continues as plans advance to present a case for acquisition of an Optronics "Photowrite" machine.

The atmospheric transmittance determinations and analysis of various factors influencing the measured radiometric results continues. An interim report on global and solar irradiance is included here.

2.4.1 Use of C.S.I.R.O. "Photowrite" Machine

In response to user requests, images additional to those mentioned in Section 2.2.3 have been prepared and sent to C.S.I.R.O. for outputting on their Photowrite machine.

2.4.2 Irradiance Measurements

Measurements of global and solar irradiance have been made by the PEL group (Wellington, Darfield, and west central New South Wales (Australia)), and by the C.S.I.R.O. group (Wellington, Sydney and west central New South Wales (Australia)) intermittently since 1972. Several radiometers have been used (Gamma Scientific (PEL) and Exotech & ISCO units (C.S.I.R.O.)). These measurements have been made for the LANDSAT bandpasses at different times of the year and are directed at determining the effect on target radiance of solar declination, latitude, and varying degrees and distributions of atmospheric haziness/cloud.

Dr P.J. Ellis (PEL) and Dr M.J. Duggin (C.S.I.R.O.) have begun an intercalibration programme for their respective radiometers so that the data which they had collected could be interrelated. The analysis of this considerable joint (Australia and New Zealand) data bank is now in progress and will form the basis for future publications.

Present findings are as follows:

1. The Gamma Scientific LANDSAT ground truth radiometer and the Exotech Model 100 LANDSAT ground truth radiometer possess different instrument response characteristics. Working from the measured output, for identical experimental conditions, via published calibration results for the different sets of equipment, and using the NASA data of Thekaekara et al (1972), the spectral solar irradiance above the atmosphere was found to differ by up to 40% between the two types of instrument. The five C.S.I.R.O. Exotech radiometers showed inter-unit agreement within 5%. These results confirm the need for more attention to be directed at determining the spectral response function for each instrument before attempting to relate their measurements one to another or to the LANDSAT MSS data. Data on the latter spectral responses has been requested from NASA.
2. A least-squares fit is being made to the global (i.e. solar plus sky) irradiance data for each set of daily data using an expression of the form -

$$I_r = \frac{r^I_0}{m} (a_0 + a_1 m + a_2 m^2 + a_3 m^3)$$

where the normal component of global irradiance is expressed as a power series in air mass m

and r^I_0 = irradiance above atmosphere in bandpass r for the peak normalised spectral response of the radiometer used

I_r = measured irradiance in bandpass r .

a_0 = constant

a_1 = constant

a_2 = constant

a_3 = constant

A typical fit is shown in Fig. 3 for October 15, 1973, Sydney, MSS Channel 7. Relationships between the regression constants and -

1. location
2. weather conditions
3. latitude
4. season (solar declination)
5. geographic variables

are under study, as is the contribution of cloud near the horizon to sky radiance. It is hoped that a better understanding of the intensity of global irradiance at the ground will be obtained for all conditions under which satellite recordings can be made.

Changes in the spectral distribution of

- (a) global irradiance at the target
- (b) atmospheric transmission

can masquerade as apparent changes in the spectral distribution of radiance detected by LANDSAT. Duggin and Ellis have considerable information on day-to-day and within-day variation in the spectral distribution of global irradiance. They believe that a better understanding of the effect of the atmosphere will lead to a better understanding of the radiometric classification limitations of LANDSAT data.

2.5 CCT Reformatting

The reformatting of complete CCT product on the IBM 370/168 has progressed to the stage where each MSS band, for a complete scene, can be written into a separate file on tape. A total of five files are used with the first holding all the "end-of-line" calibration information. Each of the four succeeding files, one for each band, contains on a pixel-by-pixel basis, the scan line data spanning the four strips for the scene. At this time other priorities have interrupted this work but the next step is to have the installation system analysts consider ways in which some aspects of file management and data transfer may be further optimised through the Job Control Language. The PL 1 programmes are optimised and operational. Following that step our first reformatted full scene will be produced. Documentation will then be prepared.

These reformatted tapes together with the original interleaved tapes will be/are available to user groups using the Ministry of Works and Development national network to this Wellington IBM 370/168.

2.6 Computer Processing of LANDSAT Subimages

During this reporting period good progress has been made in the processing of portions of LANDSAT scenes on the HP 2100 computer at PEL. Further programs have been developed and documented (McDonnell, 1976). In particular, experience gained in processing 128 x 128 pixel test images has been used in developing programs to process images of arbitrary size. At present we are limited by the computer to dealing with a single band image of maximum size 75 x 50 miles. As mentioned in Section 2.2.3 and 2.4.1, these programs have been used to prepare magnetic tapes containing enhanced images for later outputting on a "Photowrite" machine (Figure 2). The images prepared in this way have undergone a first order geometric correction which compensates for the effect of the Earth's rotation.

Improved colour composite prints of some of our 4 mile square test areas have been prepared. This has been made possible by improved displays of black and white images. The best of these were prepared for us on the ANAC Model 911/961 Digital Graphics Printer. Other good printouts were obtained using the Varian Statos 33 at the Christchurch Public Hospital. Also improved outputs are now being obtained on the Varian Statos 31 at PEL.

We have twice achieved aerial coverage of our Darfield test area coincident with LANDSAT coverage. The aircraft negatives have been scanned on the Optronics "Photoscan" machine at Massey University, Palmerston North and will be compared in the computer with the corresponding LANDSAT data.

In Part V of this report Mr B. Lean of the Forest Service comments in detail on Figure 11 of Part I of the Second Quarterly Report which showed windthrown areas in the Eyrewell State Forest. Time sequential imagery of this area is being prepared for use in timber desiccation studies to be carried out jointly with the Forest Service.

A technique for the colour enhancement of imagery was discussed in Section 3.1 of our previous quarterly report. This technique was applied to a 4 mile square area of central Christchurch city taken from a 31 October 1975 LANDSAT image. MSS bands 5, 6 and 7 were used. The image was transformed in spectral distribution space to give three new image bands which were the principal, secondary and tertiary components of the image in spectral distribution space. These new image bands were then enhanced by histogram equalisation to give the result shown in Figure 4. The principal, secondary and tertiary components are printed as yellow, magenta and cyan respectively. As intended, Figure 4 contains the full range of possible colours. However, the complexity of the colour enhanced image made it difficult to interpret. This is firstly because spectral signatures in a city area, unlike a farming area, tend to vary rapidly over a sampling distance. Secondly, the colour enhancement technique tends to amplify any noise present in the image bands. Thirdly, the noise level is greatest in the tertiary component of the final image. These effects combine to give a mottled appearance to Figure 4. Park areas show up as orange, and in particular Hagley Park in the lower middle of the picture stands out clearly. The river Avon running from the right of Hagley Park to the centre of the right hand side of the image is also evident. The central city area to the right of Hagley Park shows up as shades of blue. Lower quality housing areas to the upper right of Hagley Park have a mottled blue-green appearance, whereas high quality housing areas to the upper left of Hagley Park have a mottled orange appearance caused by the presence of more vegetation.

It was found to be much easier to interpret the black and white images containing the principal, secondary and tertiary information than the colour composite made from them. In particular, principal roading structures were evident in the principal component of the image, but were masked in the colour composites. This enhancement technique needs to be applied to images with lower frequency spatial variations before it can be properly evaluated.

2.7 Cartographic Reflector

As outlined in the Second Quarterly Report, the reflector was moved to the PEL Auroral Station at 45.04°S, 169.69°E in time for the 22 June 1976 overpass. Unfortunately cloud again prevailed but the operator was trained and briefed on the programme. For each overpass of that area (Day 8 in the LANDSAT 2 cycle) the operator acts on telexed advice from PEL (Wellington) which is based on a N.Z. Meteorological Service assessment of cloud cover probability for the area. To 2nd October only the overpasses of 2 September and 20 September were predicted as usable in terms of cloud cover, and indeed proved to be so. We await information from NASA as to whether coverage was possible. This procedure will continue until results are obtained.

The Department of Lands and Survey - our joint experimenters in this project - have recently determined the terrestrial position of the unit and have fixed alignment directions for the experiment.

Following the decrease in allowable cross track variation for

LANDSAT 2 to + 3 km and the apparently successful modification of an ISIS satellite tracking programme by Mr A.F. Cresswell of PEL, it is feasible to consider using a plane, back silvered, glass mirror for the reflector. This would produce an increased, and more uniform, radiation field at the spacecraft than is currently possible using a bowed stainless steel surface. Both units will be operated similarly to the installation reported by Evans (1975).

2.8 Data Storage, Retrieval, and Dissemination

Since the last report three more scenes have been received and disseminated to our Co-investigators.

Following the successful implementation of a scene location reference map, cited as Figure 1 of Part II of the Second Quarterly Report and reproduced here as Figure 5, our growing number of print type products are ordered according to this grid system which was developed in conjunction with Department of Lands and Survey.

LANDSAT II passes over New Zealand roughly from north to south along the orbital tracks as indicated in Figure 5. These tracks occur on successive days in the complete 18-day global coverage cycle. Days 4 to 10 cover New Zealand and this cycle figure gives the leading number in the group typifying each scene centre. The remainder is the sequential number along the track over New Zealand. The scene centres are repeatable within the scale accuracy of this location map.

In response to user suggestions we have now included in our data advice listings the cloud cover percentage and band quality figures. We also now include our own 70 mm file number and each scene's CCT status.

2.9 "PEACESAT"

Over the reporting period "PEACESAT" has been of inestimable value. Not only have the concepts of SEASAT and a Receiving Station been discussed in some depth with staff at Goddard Space Flight Centre but also the opportunities have arisen to speak about remote sensing to our colleagues around the Pacific PEACESAT network. It is true to say that New Zealand would not be as well briefed on SEASAT, or be as far ahead in feasibility discussions on a Receiving Station were it not for this mode of communication. We, at PEL, are indeed grateful to the staff of the PEACESAT network, particularly to Miss E. Flavell of Wellington Polytechnic and to Ms C. Misko in Hawaii, for their efforts on our behalf. We also very much appreciate the assistance, usually at a late hour, so freely given us by Dr R.D. Price of GSFC. His assemblage of relevant experts on more than one occasion has really boosted our programmes - present and future.

2.10 LANDSAT-C Statement of Interest

On 4 August a meeting of interested user groups was held at PEL to discuss the submission of a joint Statement of Interest to NASA for the LANDSAT-C programme. This report contained a brief from each of the thirteen contributing agencies outlining the possible projects of each agency. A summary of the projects advanced by each agency and a compromise set of coverage requests were compiled and appear in the report edited by Ellis and Thomas (1976).

2.11 Receiving Station

Interest in a Receiving Station in this country is increasing as the applicability of LANDSAT data to operational decision making becomes more apparent. This need for timely information together with the knowledge that future satellites will not carry tape recorders has focussed attention on the likely need for a Receiving Station in this geographical area. The knowledge that satellites such as SEASAT will have data rates that could possibly defy real time tape recording equipment makes the need more immediate. With future satellites in the LANDSAT series heading towards an orbital altitude of 700 km, the sharing of a Receiving Station between New Zealand and the East Coast of Australia becomes less possible. The remote sensing section have been conducting a preliminary feasibility study into the possibilities of a New Zealand station.

A working figure of 10° elevation angle may be employed as a lower tracking limit to

- (i) avoid ground topography screening;
- (ii) minimise antenna dish dimensions - desirable when considering wind/ice loading (and expense of the tracking system);
- (iii) avoid the need for "state of the art" receiving equipment rather than using currently proven and operational units.

The Remote Sensing Section of PEL have prepared coverage maps for a variety of locations in Australasia and here include that based on Wellington. Upon inspection of the coverage map (Figure 6) for 10° elevation and 700 km altitude (based on Wellington) the conclusion cited earlier that a tracking station in Australia would not service all New Zealand's interests is evident.

A tracking station situated near Wellington has the following advantages:

- (i) Coverage of all New Zealand's possible 200 mile economic zone.
- (ii) Most user head office groups have offices in Wellington and thus ready applicability of timely data is possible for decision making processes.

- (iii) Proximity to currently existing embryo interpretative facilities in Wellington.
- (iv) Proximity to central computing facilities and access to national data dissemination network.
- (v) Proximity to specialised servicing facilities.
- (vi) Trained staff familiar with all technical and scientific aspects of programme are resident in Wellington.

2.12 Satellite Tracking Programme

A satellite tracking programme developed for use with the ISIS spacecraft has been tested with LANDSAT using the only available set of orbital elements (Epoch 2/23/75).

A comparison between the predicted sub-satellite point and the co-ordinates of a series of scene centres show reasonable agreement. This is presented in Figure 7 without any allowances for spacecraft altitude influences being included.

Increased accuracy would require more comprehensive updated orbital elements.

3. ACCOMPLISHMENTS, IMMEDIATE OBJECTIVES, AND SIGNIFICANT RESULTS

3.1 Appended Results

As mentioned in Section 1 probably our major aim this quarter has been bringing the imagery to bear on investigations being carried out by user groups. The start of some of these joint programmes are reported in the appended reports. All user groups using the imagery are invited to prepare summaries for inclusion in these Quarterly Reports.

3.1.1 Forest Service

In Part V is presented the report prepared by the N.Z. Forest Service on projects they have pursued utilising the LANDSAT imagery and the facilities of the Intra Lab. Some 2 - 3 workshop days on each topic have been co-ordinated by Mr N. Ching of N.Z.F.S. Local district/project expertise, combined with broader Head Office expertise and liaison, when further combined with PEL facilities and staff has resulted in meaningful steps along each analysis path.

3.1.2 Geography Department, University of Auckland

Prof. G.R. Cochrane runs a remote sensing programme in the above department and took the opportunity during this reporting period to

visit PEL with some of his students. They brought the ground truth knowledge and extracted quite an amount of information from the imagery. Their multi topic report is included in Part VI of this Quarterly Report. This, to our knowledge, is the only remote sensing course being conducted in this country utilising LANDSAT and other imagery.

3.2 King Country Study

Government has requested that by early 1977 a land use assessment and capability report be prepared for the King Country region of the Central North Island. The area covers native forest and agricultural land to the west of Lake Taupo. Such a detailed assessment requested over a relatively short time period would seem to be a "tailor-made" problem for LANDSAT imagery as opposed to detailed ground survey techniques. The coarser classification classes of: indigenous (native) and exotic (man planted) forests, gross categories of agricultural usage (alfalfa and cereal crops), urban areas, topographic relief, water catchment areas; may all be easily identified from the imagery.

The best image currently to hand is 2389-21172 recorded on 760215. Part of this image covering the region of interest has been enlarged and photographically enhanced to reinforce the dynamic range of the supplied 70 mm product over the forest and agricultural areas. Following discussions around the colour additive viewer with Forest Service and Lands and Survey staff, a range of colour balance composites were produced and circulated to the investigatory groups in the New Zealand Forest Service, the Department of Lands and Survey and the Geography Department, University of Auckland. Some initial results are included in other parts of this report and a more cohesive study is expected to be included in the Fourth Quarterly Report.

Further satellite coverage of the region before December would be of great benefit - weather and spacecraft priorities permitting.

3.3 St. Arnaud Study

PEL, together with the N.Z. Forest Service and Department of Lands and Survey, have been approached by the National Parks Authority for assistance in determining the viability of extending a currently minimally developed skifield on the slopes of Mt. Robert in the St. Arnaud range as compared to developing an adjacent area.

Obviously this type of study is best served by a library of repeated coverage over a number of seasons and years. The first step was to ascertain if LANDSAT imagery was suited to the task.

An enlarged and photographically dynamically enhanced section of scene 2282-21252, recorded on 751031, was prepared of the region of interest. A colour composite and colour isodensitometer image were prepared, after consultation with the Forest Service, and are commented on further in section 3.3.1 and in Part V of this Report.

It quickly became apparent that this area possessed a number of striking geological features and other balances were used in preparing

additional colour composites of this region. This is commented on further in Section 3.3.2.

3.3.1 Snow Coverage

From the enlarged and enhanced section of scene 2389-21172 it has become apparent that band 4 often reveals great detail in snow areas whilst band 7 starkly reveals topographic detail.

A black and white enlargement of band 4 is presently being correlated with ground contour topographic mapping and vegetative type information.

It has been found that a colour composite prepared by printing band 4 positive transparency through a blue filter, band 5 negative transparency through a red filter and band 7 negative transparency through a green filter revealed the most detail in the snow, seen as a reddish colour, and surrounding vegetative cover. (This print is Figure 5(b) in Part V.)

As band 4 appears to be most applicable to snow assessment a colour isodensitometric image was prepared from the enlarged band 4 positive transparency. This is included as Figure 6 in Part V of this Quarterly Report. This image is presently being projected onto base map material (as outlined in Section 2.2.1) by Forest Service staff.

Following correlative work between the above three techniques, an assessment of the applicability of LANDSAT imagery to this snowfield evaluation task should be possible. Currently this evaluation is hampered by a lack of ground truth data in the snow area of the image studied. Consequently, from this image, the best locations for snow monitoring transect lines have been determined and data will be obtained along these set lines over the potential and control slopes on the days of predicted satellite overpass. Snow depth, type, moisture content, and climatic conditions will be measured. For times of good satellite and ground truth coverage coded CCT print outs/supervised clustering techniques will be used.

This is an ongoing evaluation and relies upon good historical LANDSAT coverage.

3.3.2 Soil/Vegetation/Geological Typing

This St. Arnaud area is a most interesting one geologically. Not only does a main fault line between the Indian and Pacific tectonic plates run through it, but evidence for lateral displacement and uplift is contained in this relatively small area. From differing geological basal material, changes in superposed soil types can be expected. These changes are then reflected in the vegetation.

By experimenting with colour balances in the additive viewer subtleties in vegetation MSS hue can be made more apparent. This relation between such hue variations and the underlying factors has just commenced and will be discussed in the next report.

3.4 Spectral Signature Analysis

Preliminary results are presented here of an analysis of spectral signatures present in the 31 October 1975 LANDSAT II scene 2282-21254 of our Darfield test area. The "signatures" were derived from the LANDSAT II digital radiance levels, as discussed in Section 2.7 of our Second Quarterly Report and using ground truth information gathered at the time of the satellite overpass. Five distinct land categories were apparent. These are shown in Table 1, where for each category and each spectral band the mean and, in brackets, the range of each signature is shown. The sun elevation angle at the time of satellite overpass was 43°. The general category "grass" covers a wide range of overlapping spectral signatures and includes various heights, types and mixtures of grass, clover and lucerne. The spectral signature of lucerne was higher in bands 6 and 7 than the other grass types. As the lucerne height increased from 4" to 12" the signatures decreased slightly in bands 4 and 5, and increased markedly in bands 6 and 7. High lucerne was in fact separable from the other grass types. The signatures for barley and wheat though close, were separable in the test area.

Table 1

Mean and range of LANDSAT II spectral signatures for five land use categories at our Darfield test site on 31 October 1975

Category	MSS Band			
	4	5	6	7
Forest	11 (10-13)	11 (8-13)	33 (25-40)	19 (14-24)
Wheat	18 (16-20)	17 (14-20)	59 (56-62)	32 (28-35)
Barley	21 (20-22)	22 (20-23)	59 (54-64)	28 (27-30)
Worked	25 (22-28)	32 (27-36)	38 (34-42)	18 (16-21)
Grass	16 (14-19)	15 (11-19)	75 (63-89)	44 (35-54)

3.5 Lectures and Visitors

The potential applications of remote sensing techniques in New Zealand have been well publicised during this reporting period. The staff of the Remote Sensing Section have given lectures to the New Zealand Physics Conference, the Wellington Branch of the Royal Society of New Zealand, IBM Management Courses, the Department of Lands and Survey, PEL staff, potential co-investigators in the LANDSAT C programme and to the Oceanographic Institute of DSIR. In addition, over 40 interested groups have visited the Remote Sensing Laboratory at PEL during this last reporting period.

4. PUBLICATIONS

4.1 PEL Reports

P.J. Ellis and I.L. Thomas Eds. "New Zealand participation in the LANDSAT C program: Statement of Interest", PEL Report No. 544, August 1976.

M.J. McDonnell "Computer programs for processing LANDSAT imagery on an HP 2100 computer: Part II", PEL Report No. 545, October 1976.

4.2 Newsletter

During this reporting period we have circulated the second of our informal "Remote Sensing Newsletters". Since the first issue the circulation list has doubled to around 120 addressees throughout New Zealand, Australia and the Pacific. With this increase comes the need for more automated reproduction techniques and the Government Printer has been of inestimable assistance here. This reflects the rapidly increasing awareness and interest being shown in remote sensing in this country.

The philosophy has changed slightly from the first edition inasmuch that we now try to include longer notes on some aspects of remote sensing amongst the chronicled informal news snippets.

We regard this newsletter as being a necessary informative vehicle for increasing general awareness and bringing, say, the merits of; colour composite print/transparency, photographic product/CCT, to as wide an audience as possible. It is our policy to circulate it free of charge - in line with NASA policy.

5. PROBLEMS

5.1 Comments on "Non-U.S. Catalog"

It would seem from the listings in the "Non-U.S. Catalog" circulated to us that some scenes have been recorded over this country falling within the terms of our Standing Order Requests and which have not been received by us. This has only just come to our notice and we shall cite specific scene numbers in the next report. We have also received some imagery that does not appear in the "Non-U.S. Catalog". The images 2391-21273, 2391-21280 and 2391-21282 have been received and are not mentioned in the "Non-U.S. Catalog" for February 1976. In addition, in the same catalogue the cloud cover figures are often in error where the images are indexed under their latitude and longitude. For example, on page 88 the cloud cover for many scenes is given as exceeding 100%.

6. ACKNOWLEDGEMENTS

The work we have been able to undertake would have been impossible without the ever ready, high quality and willing resource facilities provided by the rest of PEL and our user groups. In particular, our programme relies upon:

within PEL - the Instrument Workshop
the Photographic Section
the Photometry Section
the Typing Section
the Library
the Electrical Engineering Division
the Computing Section

within Chemistry Division (D.S.I.R.) -

the Photographic Section

and our user groups in -

Lands and Survey
Forest Service.

The cheerful assistance of the "PEACESAT" network has also been of great assistance to our programme in New Zealand and to other countries around the Pacific.

All this co-operation would be largely wasted were it not for the thoughtful and considerable assistance so readily given us by the NASA staff at Goddard Space Flight Centre. Our negotiations within this country on LANDSAT-C, SEASAT, and the Receiving Station have been based on the steady flow of documents, comments and PEACESAT discussions originating from these NASA staff. In particular, we should like to express our appreciation of the help given us by Dr R.D. Price often at rather inconvenient times of the local night. The guidance given us by our technical monitor Dr J. Broderick is also much appreciated as we attempt to liaise correctly with NASA and EROS.

We would also like to thank the staff of the EROS Data Centre for all their efforts on our behalf, particularly over this reporting period by including more packing in the CCT products and in their continued prompt responses to our requests for "GEOSearch"-es.

7. REFERENCES

(See also Section 4.1)

Evans W.E. (1975) "Marking LANDSAT images with small mirror reflectors" NASA Earth Resources Symposium Vol I.B
p 1185, June 1975.

Thekaekara et al (1972) "Proposed specification for the
solar and air mass zero solar spectral irradiance"
NASA SP-298 Space Simulation 1972 Paper No. 82 155-968.

220EC75 C 538-43/E176-45 N 538-45/E176-51 MSS 45 7 R SUN EL49 R2081 191-4659-A-1-N-D-2L NASA ERTS E-2334-21123-8 01

E176-301

E177-001

E177-301 5038-001

220EC75 C 538-43/E176-45 N 538-45/E176-51 MSS 45 7 R SUN EL49 R2081 191-4659-A-1-N-D-2L NASA ERTS E-2334-21123-8 01

17a

10C-2513

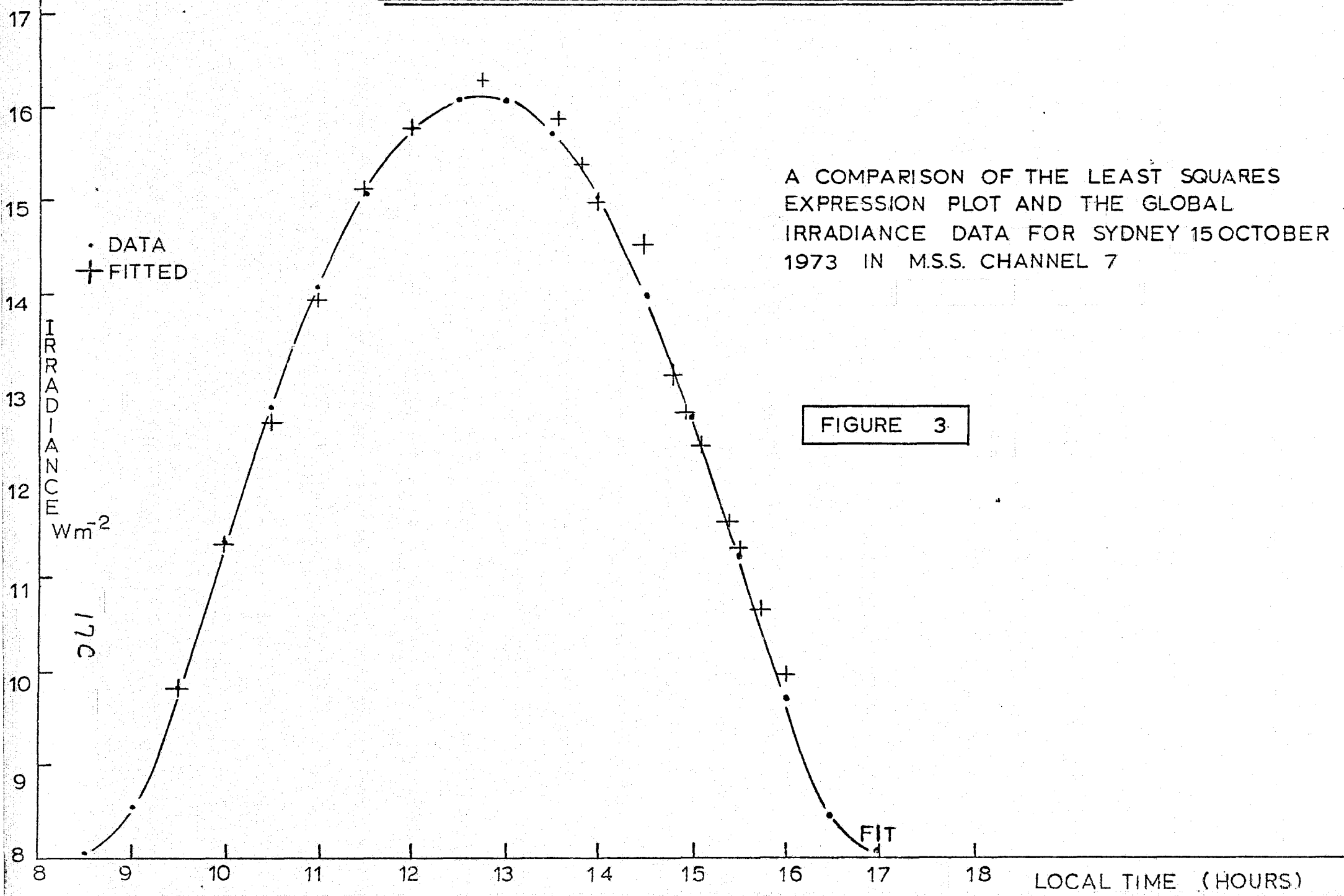
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Figure 2 - A colour composite image showing a 25 mile square area including the Kaingaroa State Forest. The image was computer enhanced at PEL and written on to a photographic negative by an Optronics photowrite machine. Bands 4, 5 and 7 are printed as yellow, magenta and cyan respectively.

Wm⁻²

GLOBAL IRRADIANCE AND LEAST SQUARES EXPRESSION



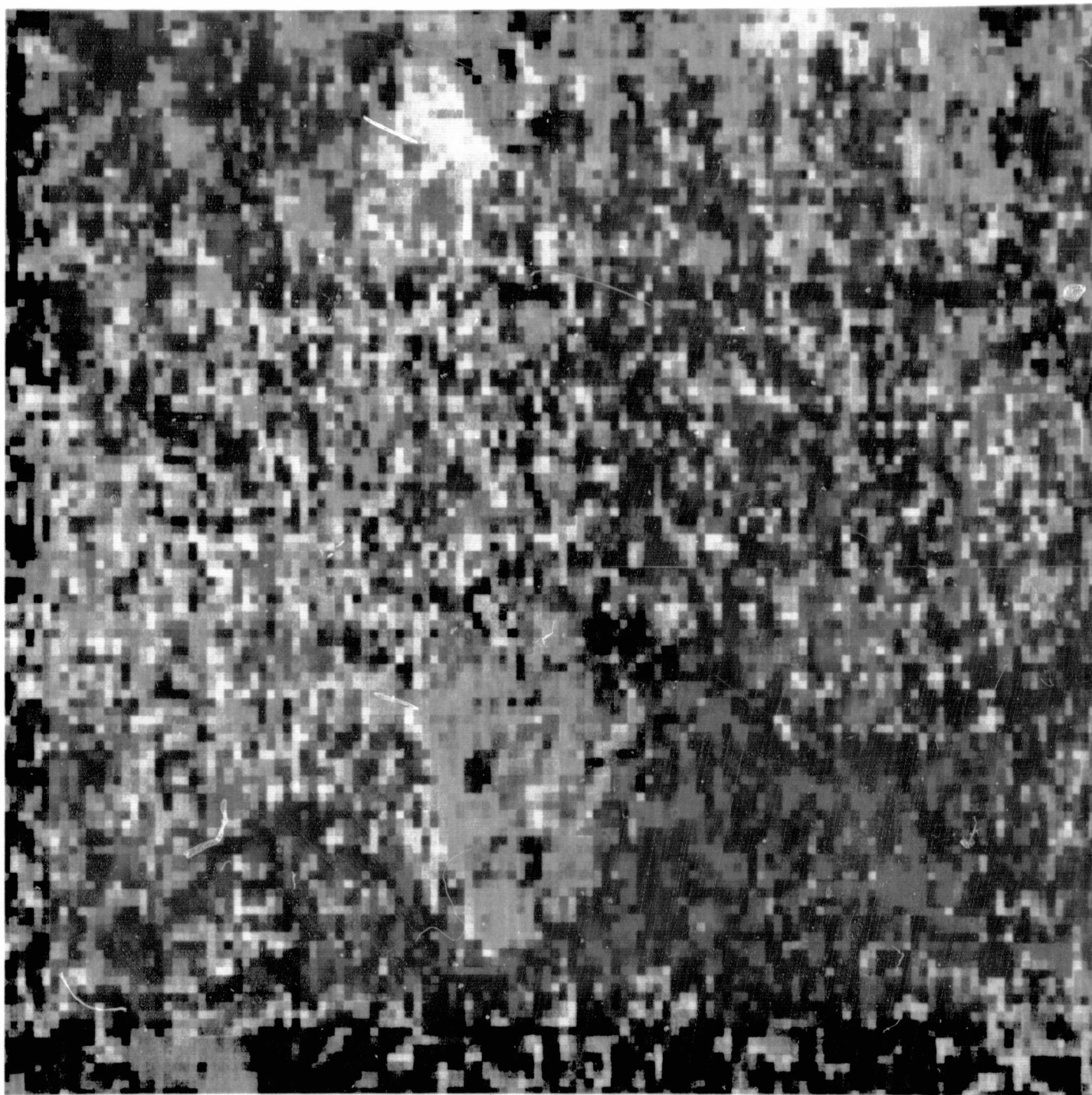


Figure 4 - A colour enhanced image of the central Christchurch city area. The principal, secondary and tertiary image components are printed as yellow, magenta and cyan respectively.

LANDSAT 2

Line represents Satellite track.

Area covered by one scene.
o represents scene centre.

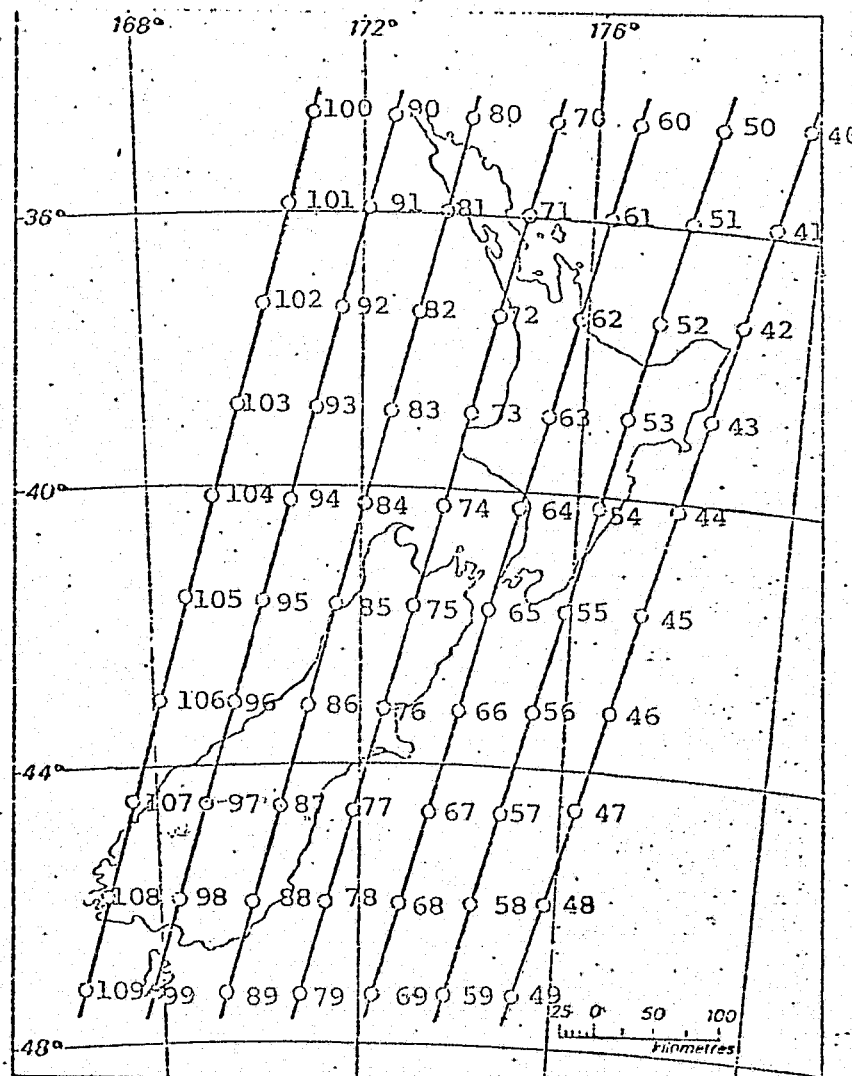
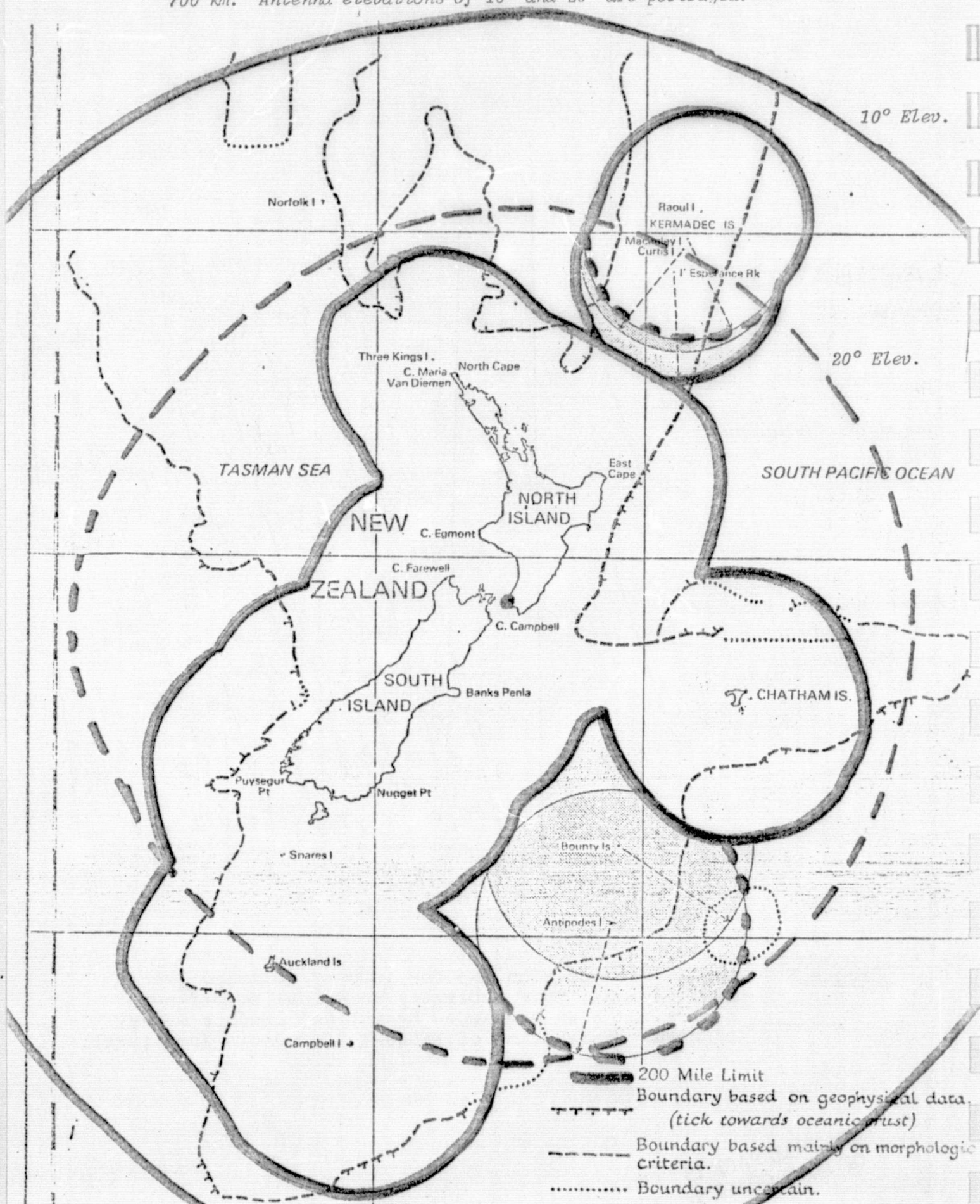


Figure 5

Geographic location map for imagery recorded over New Zealand. This arbitrary numerical co-ordinate system has been developed by PEL and Lands & Survey to assist indexation of LANDSAT 2 products (see text).

ORIGINAL PAGE IS
OF POOR QUALITY

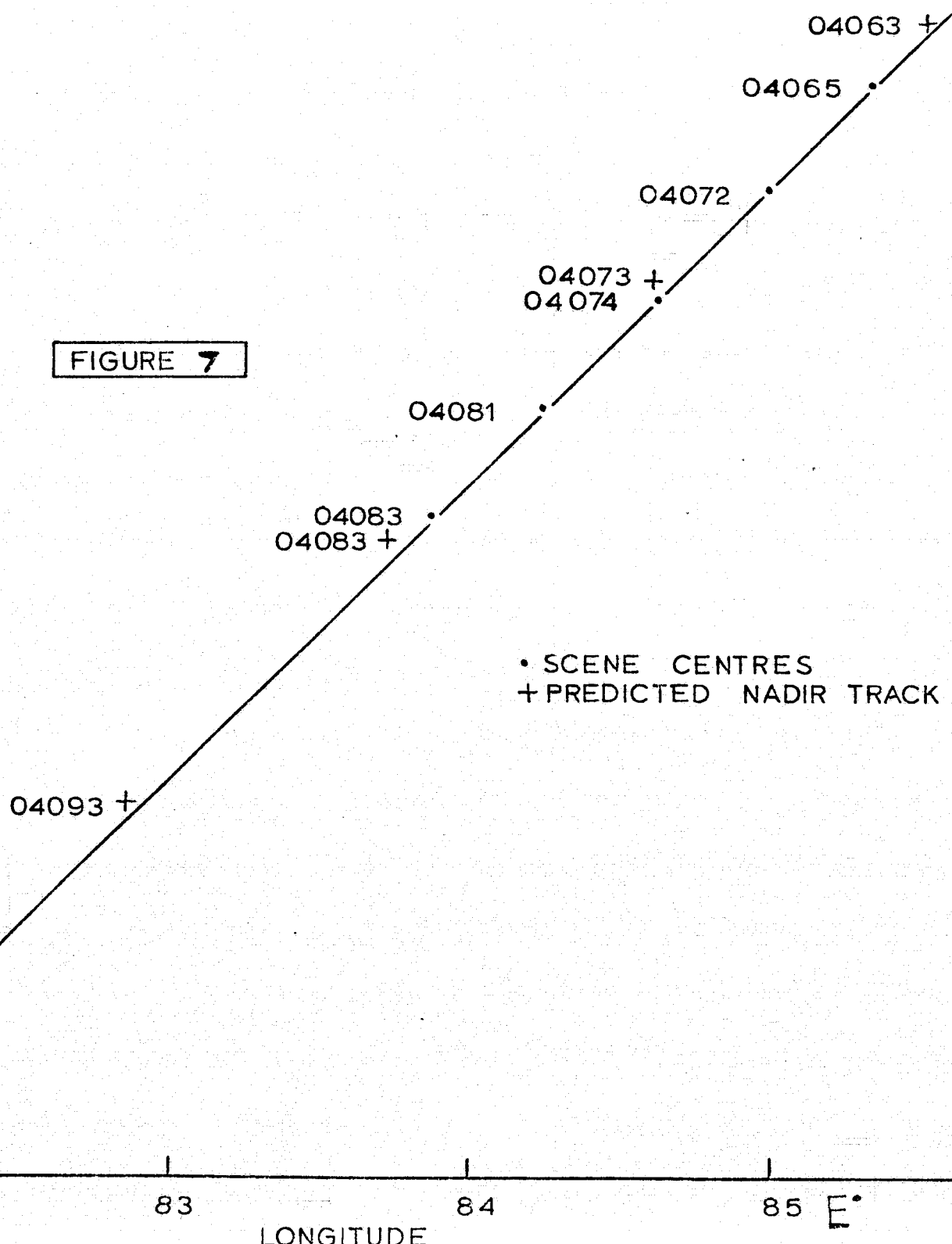
Diagram illustrating the possible 200 mile economic zone including areal coverage possible from a Wellington receiving station with a satellite altitude of 700 km. Antenna elevations of 10° and 20° are portrayed.



A COMPARISON OF THE ACTUAL SCENE
CENTRE "TRACK" AND PREDICTED NADIR
TRACK FOR ORBIT 438 OF LANDSAT 2.

TIMES ALONG TRACK IN STANDARD NASA FORMAT.

FIGURE 7



PART II

SEISMOTECTONIC, STRUCTURAL, VOLCANOLOGIC AND
GEOMORPHIC STUDY OF NEW ZEALAND

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Telephone No.: Wellington 699-059

Authors:
Mr P. Oliver
Mr K. Berryman

FIGURE CAPTIONS

Figure 1 Major (thicker lines) and minor (thin lines) lineaments observed on images of MSS bands 6 and 7 of the Southern Alps scene number 2409-21293.

Figure 2 Colour composite of scene 2409-21293 70 mm negative transparencies produced on a colour additive viewer.
(MSS band 6 printed through a green filter)
(MSS band 7 printed through a red filter)

Figure 3 Northwestern Tararua lineament location extended from LANDSAT scenes 2281-21194 and 2299-21190.

LANDSAT IMAGERY PROGRESS REPORTLANDSAT IMAGERY OF THE SOUTHERN ALPS

A LANDSAT image of the sparsely vegetated to non-vegetated Torlesse Supergroup sedimentary rocks, that make up much of the central Southern Alps of the South Island, was recorded by LANDSAT II on the 6th March 1976 (2409-21293). This was amongst the first cloud and haze free images of the Southern Alps to be obtained. Snow cover was at a minimum after the summer thaw, and was confined to the highest peaks.

The black and white images were examined for lineaments and lithologic boundaries. Fault controlled lineaments were visible as straight sided valleys and straight erosional features, although some curved lineaments also occur. The fault controlled lineaments could not always be distinguished from those controlled by bedding or structures related to lithology. Lithologic boundaries were not generally visible, although parallel sequences of dark and light bands, that did not appear to be erosional features, and which could be traced over adjacent ridges, could be interpreted as large scale lithologic units. The resolution of the LANDSAT images is outside the range of the majority of bedding structures in these Torlesse rocks (commonly less than 20 m).

Lineaments were found to be most readily visible on positive prints of MSS bands 6 and 7. MSS band 4 showed lineaments of major valleys only, while MSS band 5 showed an intermediate number between those of MSS bands 4 and 6. A combination of lineaments from images using both MSS bands 6 and 7 gave the best results. These are given in Figure 1, in which the thick lines represent the larger lineaments and the thin lines represent the smaller lineaments. The lineaments observed independently in the black and white images using MSS bands 6 and 7 were also observed in a colour composite of these two bands (Figure 2). The small scale lineaments were more clearly seen in the 9 inch black and white positive transparencies and when viewed directly on the colour additive viewer, than on the black and white or colour composite photographs respectively.

The lineaments shown in Figure 1 are predominantly the result of erosion along fault zones, and along bedding planes. The lineaments formed along the sides of many of the major valleys are a result of glacial erosion, and may or may not be formed along fault zones.

Known faults such as the Alpine Fault, Ahaura Fault, Hope Fault and Harper Fault were clearly visible in the LANDSAT images.

The lineaments represented by the thin lines in Figure 1 are of two types. One type is formed by small straight valleys which may have formed along faults, bedding planes, lithologic boundaries or have resulted from slope controlled erosion. The other type consists of small parallel sets of lineaments which, when formed across ridges,

appear to be controlled by bedding or lithologic units.

To establish ground truth for these lineaments, extensive field mapping would be required, together with a study of low altitude aerial photography. In this respect these LANDSAT images provide a useful base for further work.

GENERAL COMMENTS ON IMAGERY

The first colour "Photowrite" image, of the central North Island, has been obtained. This has a scale of approximately 1:250,000. Although MSS band 4 was used in the colour composite, the image shows a considerable amount of detail (band 4 is generally the least useful for showing geological features). Major faults in the Taupo area can be recognised and also faults in the northern Kaimanawa Range. The nature of these faults is at present undetermined, but they are likely to be of considerable structural importance as they are near the major tension and shear zones of the central North Island.

As part of a continuing study, false colour images of many parts of New Zealand have been prepared by the Remote Sensing Section of PEL, for the purpose of Quaternary Tectonics (see Second Quarterly Report, No. 531, June 1976). Further work on using different combinations of filters, band combinations, and colour intensities is required to obtain maximum benefit from these colour composite images.

LINEAMENTS ON LANDSAT IMAGERY OF THE WELLINGTON DISTRICT

In addition to the known active strike slip faults in the Wellington region, there are numerous known lineaments of varying definition. A lineament that extends from Takapu Valley (near Wellington) to Moonshine Valley was mapped as a fault at its northern end, on the basis of its linearity, by Kingma (1967). A detailed study of air photographs failed to find any evidence of Late Quaternary activity. This lineament is clearly visible on LANDSAT images 2281-21194 (30th October 1975) on MSS bands 4, 5 and 6.

On the north western flank of the Tararua Range a well developed lineament is visible in the LANDSAT monochrome positive photographs of 2299-21190 for all bands. The lineament is seen most clearly on bands 4, 6 and 7. A colour composite of scene 2299-21190 using the PEL standard colour balance (see section 2.2.1 of Part I of this report) also showed this lineament clearly. It appears to merge with the north end of the mapped Wellington Fault (known Late Quaternary activity), and the feature can be traced continuously south along the valleys of the Mangaho, Otaki, Waiotoura and Akatarawa West Rivers. Kingma (1967) mapped faults in parts of these river valleys, but it is now apparent that one major feature traverses this part of the range. In the northern Tararuas the lineament is well defined and has a similar physiographic development and strike to the Wellington Fault. It may also be an active Fault.

The continuity of the northwestern Tararua lineament with the Takapu-Moonshine lineament near Wellington suggests that this continuous feature could be part of the regional active fault system. Aerial oblique photographs of parts of the Mangahao-Takapu lineament have been taken, and field work to establish ground truth is planned.

Reference:

Kingma, J.T. 1967. Geological Map of N.Z. 1:250,000.
Sheet 12, Wellington.

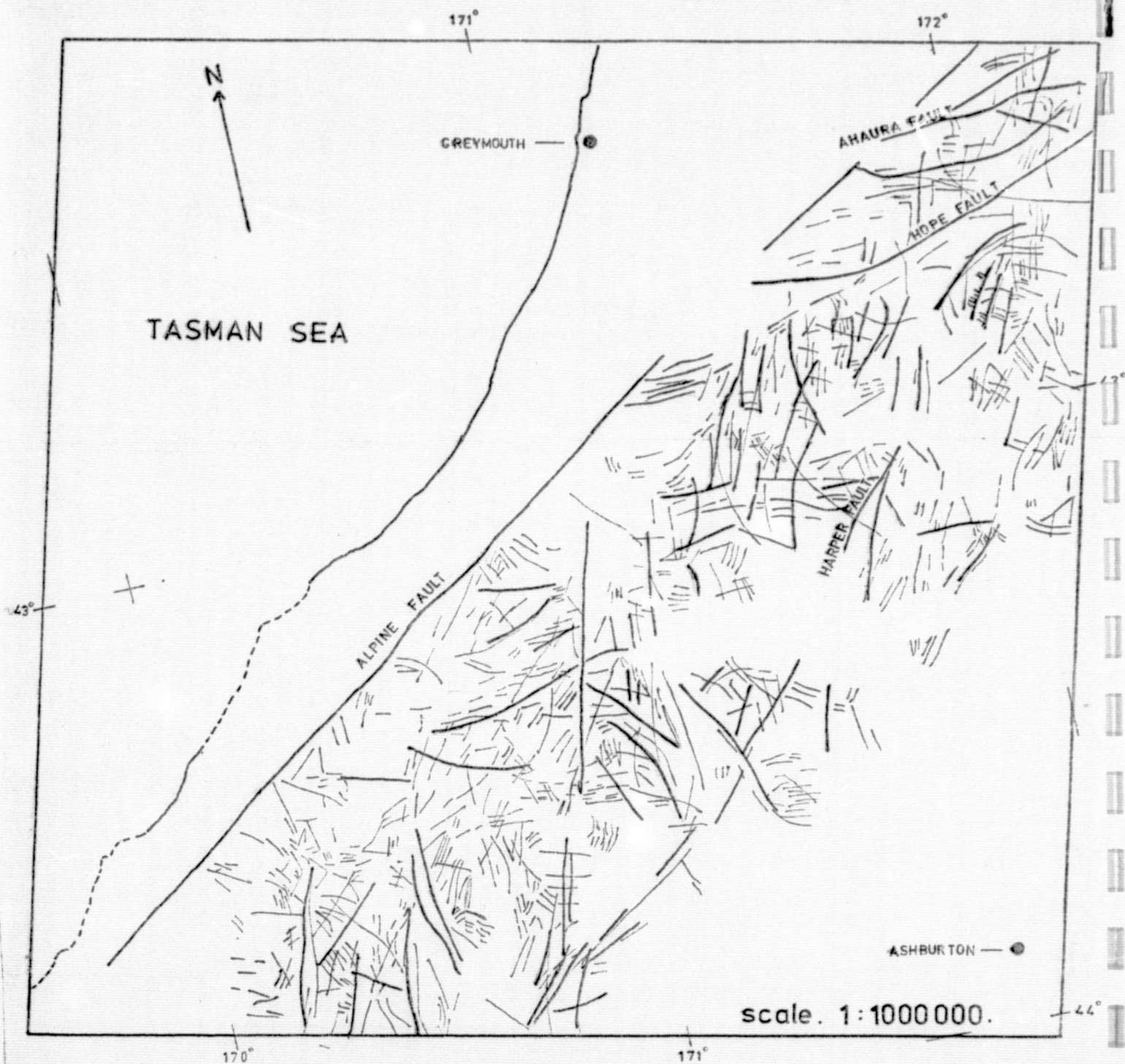


Figure 1

Major (thicker lines) and minor lineaments (thin lines) observed on images of MSS bands 6 and 7 of the Southern Alps, scene number 2409-21293.

18-3-a

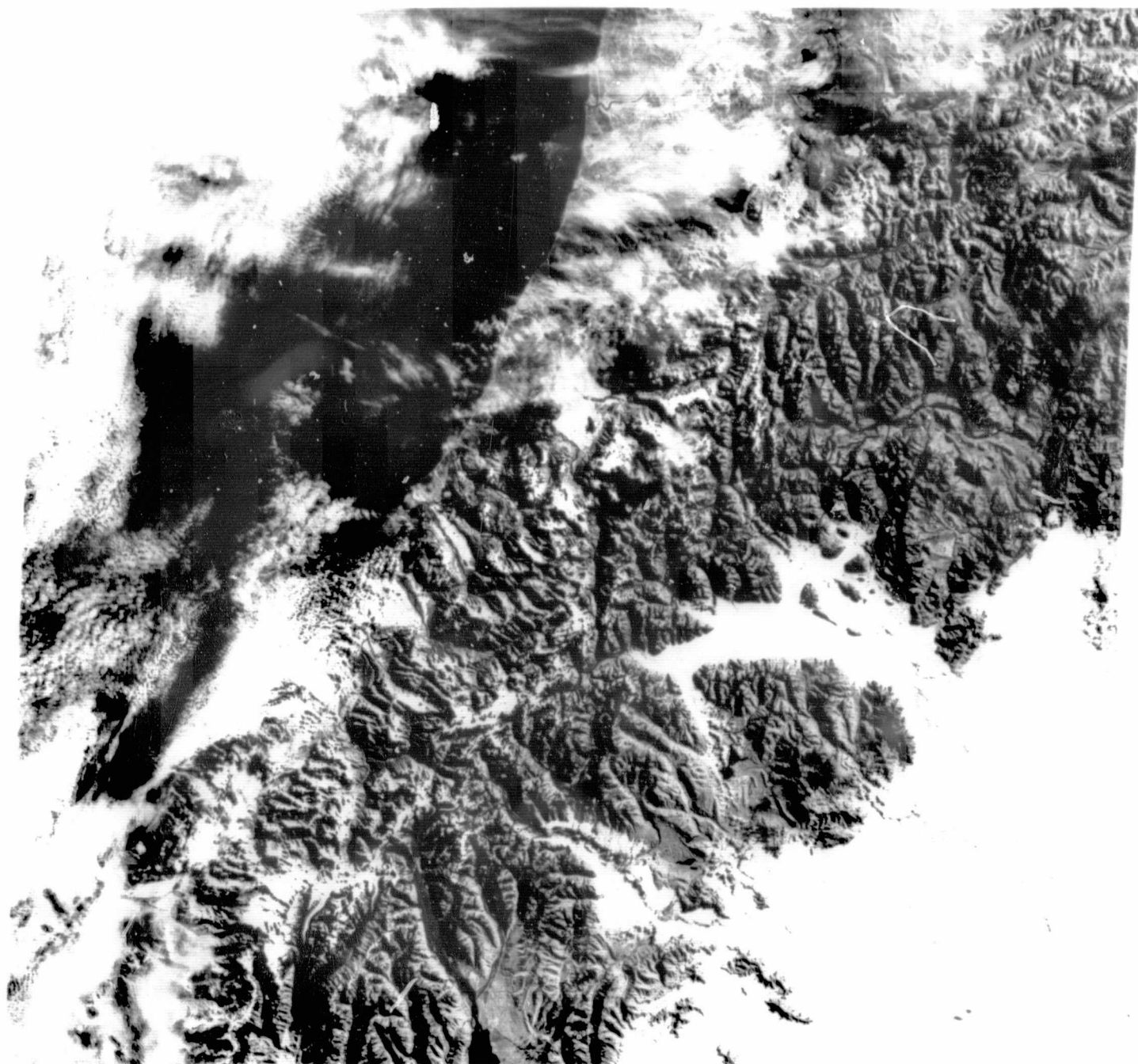


Figure 2

Colour composite of scene 2409-21293 70 mm negative transparencies produced on a colour additive viewer.
(MSS band 6 printed through a green filter)
(MSS band 7 printed through a red filter)

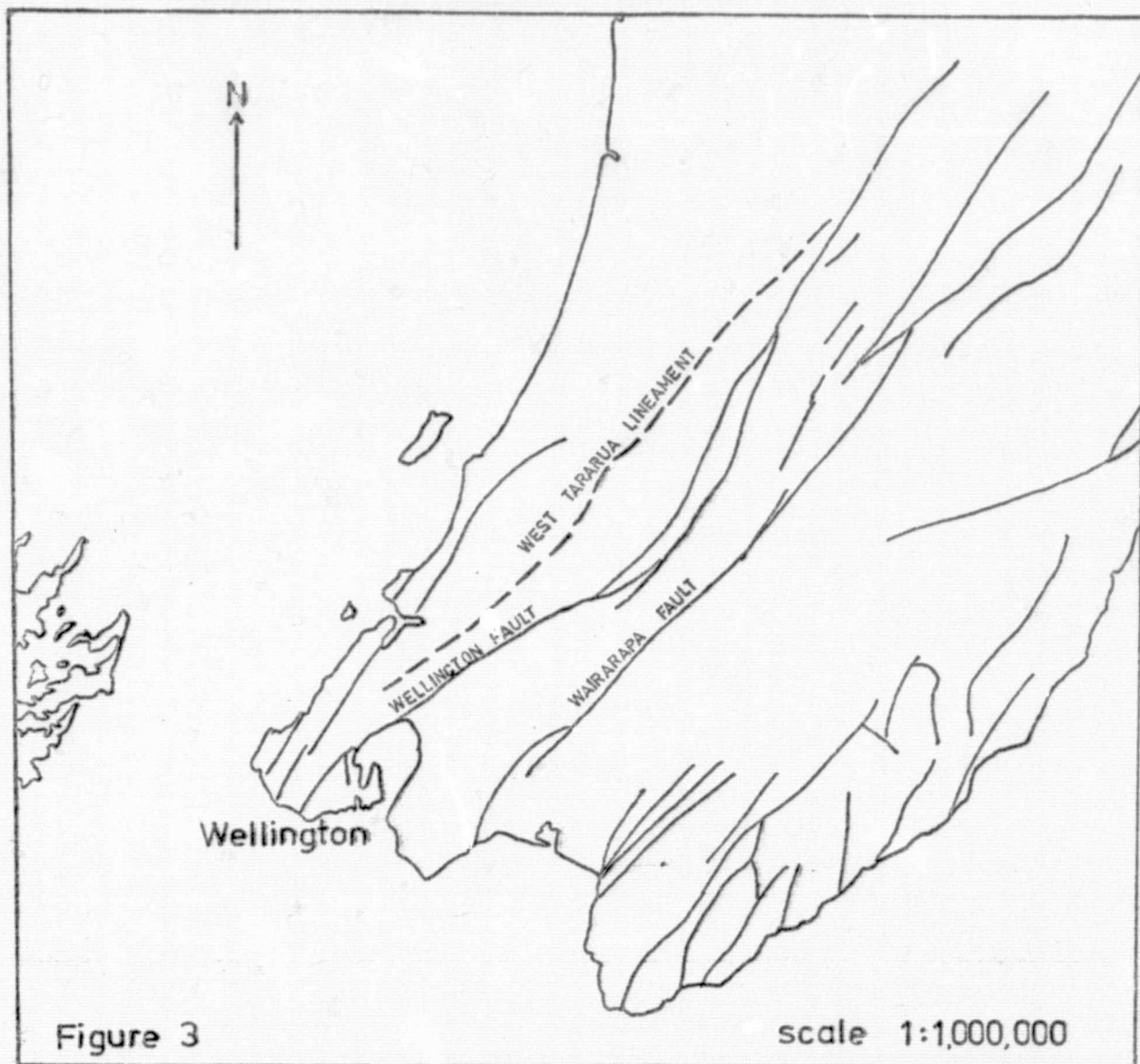


Figure 3 Northwest Tararua lineament location extended from LANDSAT scenes 2281-21194 and 2299-21190.

PART III

INDIGENEOUS FOREST ASSESSMENT

Investigation No.: 2823 B

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FIGURE CAPTIONS

Figure 1

An overlay for Figure 1 of part IV of the Second Quarterly Report LANDSAT II Investigation Program No. 28230 showing an apparent delineation between a mixture of Nothofagus menziesii, Fagaceae (silver beech) and Nothofagus fusca, Fagaceae (red beech) and Nothofagus cliffortioides, Fagaceae (mountain beech). The red, silver beech complex is generally found at lower altitudes than the mountain beech which is on the left of the dotted line.

Figure 2(a)

A panchromatic aerial photograph of part of the referenced LANDSAT scene taken on 25 January 1968 at 1030 NZST from 25 000 ft.

Figure 2(b)

An overlay for Figure 2(a) showing the delineation between the forest types on the small portion of the enhanced LANDSAT image. The silver/red beech and mountain beech regions are indicated.

INDIGENOUS ASSESSMENT

A number of false colour enhancements of LANDSAT images have been evaluated to determine their usefulness for distinguishing signature differences among forest types.

In Figure 1 of Part IV of the Second Quarterly Report, which is a combination of MSS band 4 negative transparency and MSS band 7 positive of scene 2390-21240, areas of a mixture of red and silver beech could be distinguished from mountain beech. An overlay for this referenced colour composite showing the delineation is included here as Figure 1. Panchromatic aerial photography was also used in delineating the region of Nothofagus menziesii, Fagaceae (silver beech) and Nothofagus fusca, Fagaceae (red beech) from the regions of Nothofagus cliffortioides, Fagaceae (mountain beech). The area covered by such an aerial photograph (Figure 2(a)) is indicated on Figure 1. The overlay in Figure 2(b) depicts this boundary between the two beech regions on a larger scale than in Figure 1.

Enhancement of the above LANDSAT image to remove any effects due to topographic relief and more extensive aerial photographic cover are planned to ensure that the apparent differences are due to the differences in spectral signatures of the species, and not due to solar elevation or topography.

Digital output from three areas of indigenous forest has been visually evaluated for LANDSAT scene 2334-21123. Using MSS band 7 digital output radiance levels 12 - 25 defined beech (Nothofagus spp.) and levels 3 - 9 defined mixed hardwood and podocarp species (Podocarpaceae: Podocarpus spp., Phyllocladus spp., Dacrydium spp. and many families of the order Dicotyledones). Further areas containing these forest types will be investigated, as digital information becomes available. The subtle differences discovered on the digital information are not apparent on the photographic products. (The above scene was recorded on 22 Dec 1975 GMT.)

An area of pure beech (Nothofagus spp.) was studied to determine if its spectral signature was influenced by slope and aspect. However, the only scene for which digital information was available had a solar elevation of 15 degrees making any comparison of aspects almost impossible. There was no apparent difference with changing slope on the image studied. As soon as imagery is available with a higher solar elevation, further comparisons will be made.

Progress during this reporting period has been slower than expected due to poor weather conditions. This has hindered field work and prevented aerial photography being obtained. Also, scanning microdensitometry equipment which has been expected for some time has not been delivered making quantification of photographic information impossible.

ASSESSMENT OF DOTHISTROMA PINI IN KAINGAROA FOREST

The average spectral signature, determined from a coded print out of the radiance levels from the relevant section of the CCT of scene number 2334-21123, for each of 17 compartments has been correlated with a subjective estimate of disease level in these compartments. No significant correlation has been found to date. Several possible explanations exist for this lack of correlation. The compartments selected were not of the same age and stocking and the timing of the visual assessment and the LANDSAT imagery were not synchronous. To eliminate as much initial variation as possible compartments with LANDSAT coverage available will be stratified into age and stocking classes for further evaluation.

Field and large scale photographic assessment of areas of infection are continuing. It is hoped that these studies may bridge the gap between LANDSAT imagery and field assessment.

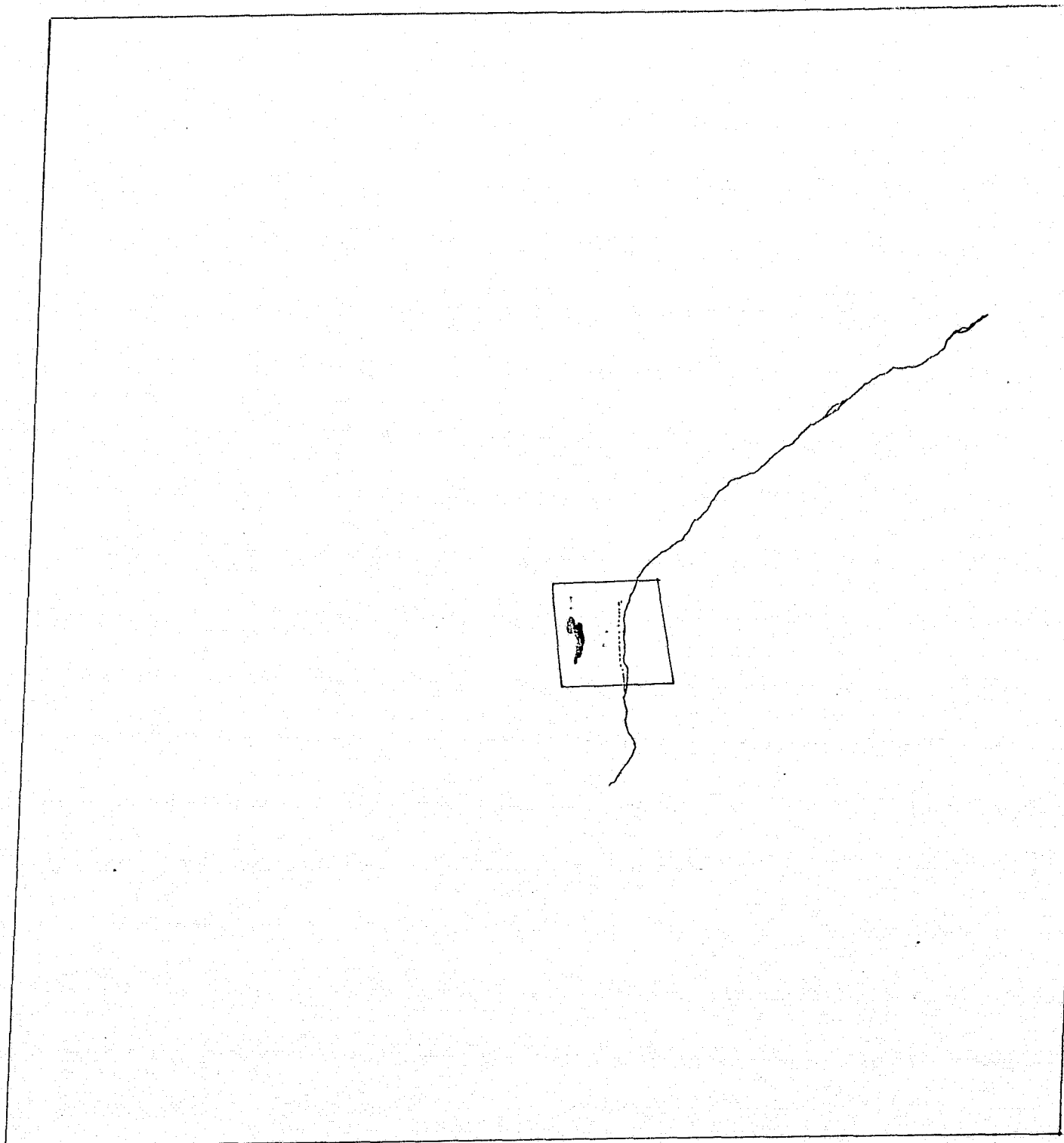


Figure 1

An overlay for Figure 1 of part IV of the Second Quarterly Report LANDSAT II Investigation Program No. 28230 showing an apparent delineation between a mixture of Nothofagus menziesii, Fagaceae (silver beech) and Nothofagus fusca, Fagaceae (red beech) and Nothofagus cliffortioides, Fagaceae (mountain beech). The red, silver beech complex is generally found at lower altitudes than the mountain beech which is on the left of the dotted line.

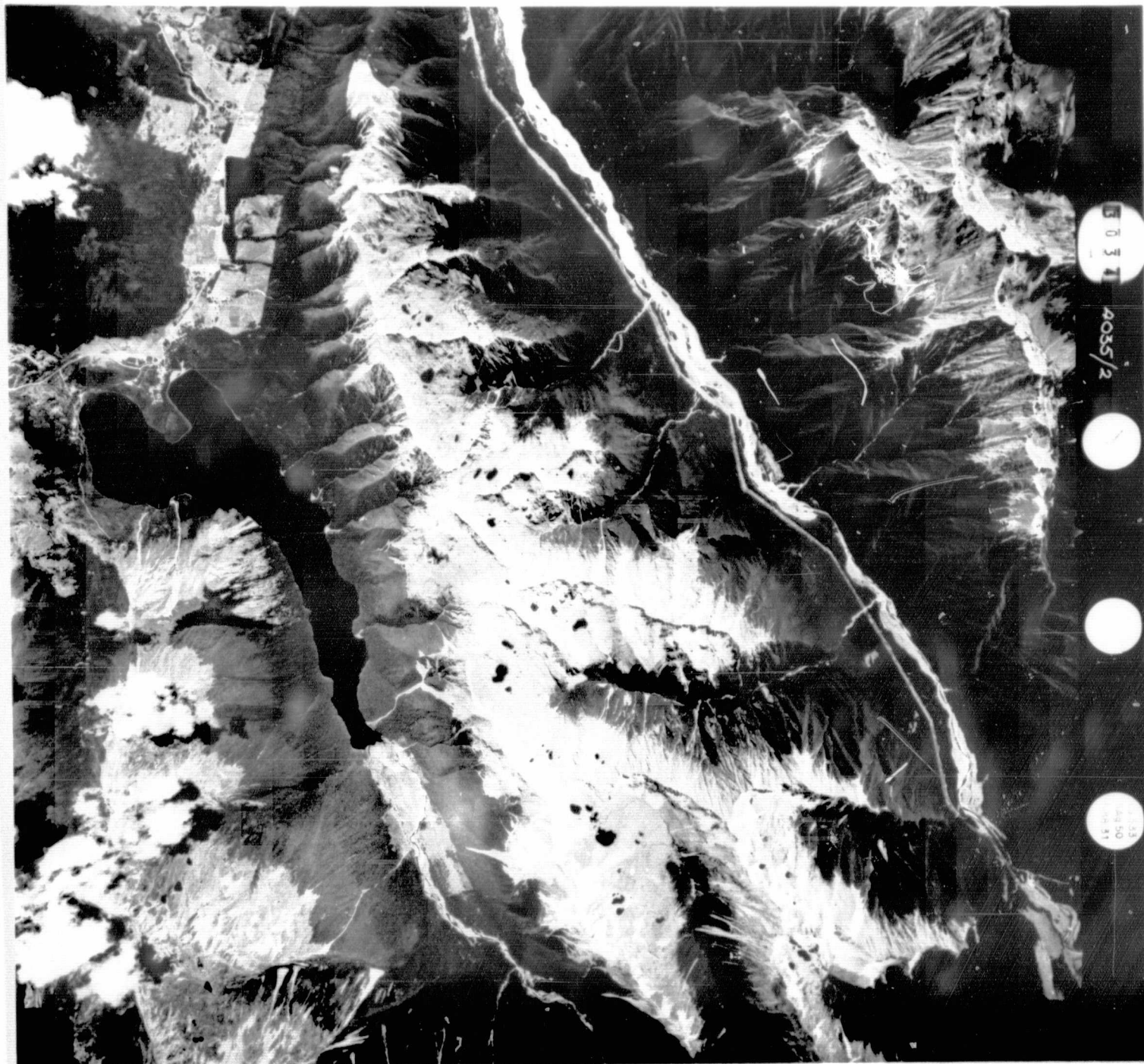


Figure 2(a)

A panchromatic aerial photograph of part of the referenced LANDSAT scene taken on 25 January 1968 at 1030 NZST from 25 000 ft.

19-2-B

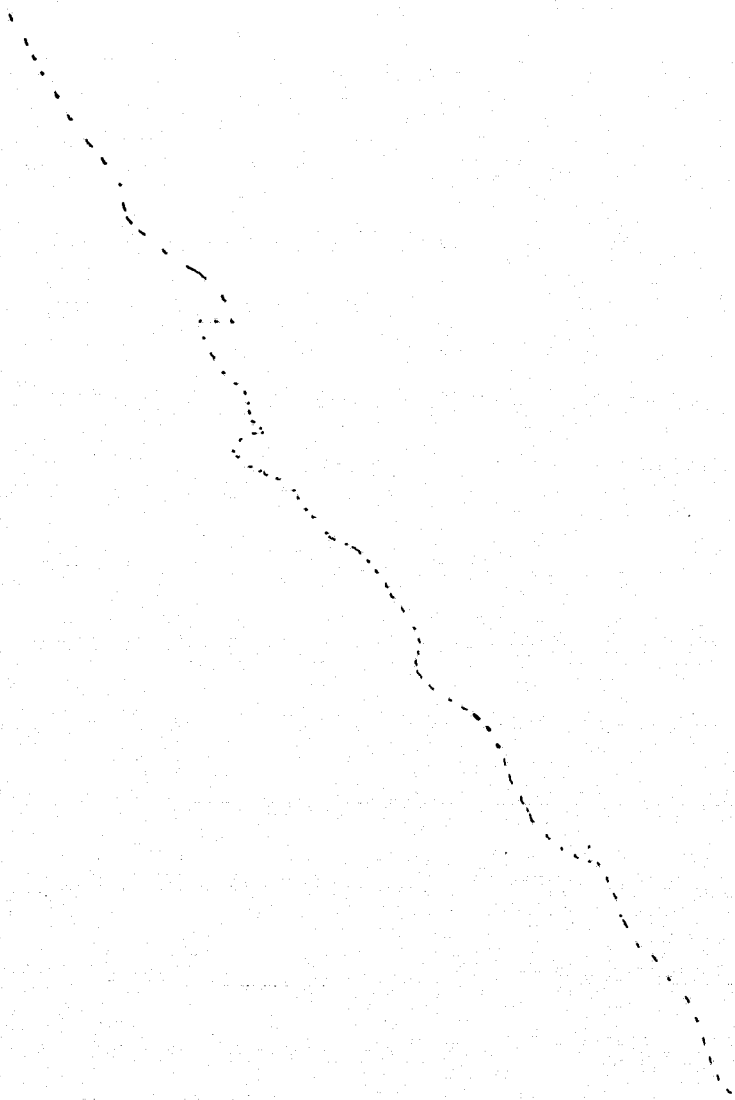
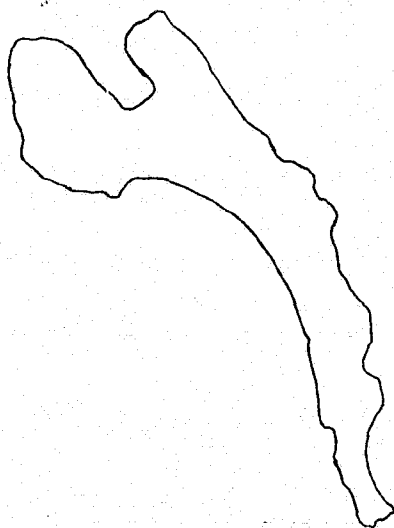


Figure 2(b)

An overlay for Figure 2(a) showing the delineation between the forest types on the small portion of the enhanced LANDSAT image. The silver/red beech and mountain beech regions are indicated.

PART IV

MAPPING LAND USE AND ENVIRONMENTAL
STUDIES IN NEW ZEALAND

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2823C

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Location map of North Island

Location map of South Island

Hillshading for NZMS 262 series

Fig. 1

" " NZMS 242 series

Fig. 2

Land Use Map Legend

Fig. 3

Reflector Alignment Device

Fig. 4

Alignment Device Protractor

Fig. 5

Control Plot Marlborough Sounds

Fig. 6

1:25,000 comparison plot

Fig. 7

INTRODUCTION

Up until the submission of our Second Quarterly Report our efforts had been concentrated almost exclusively on the cartographic applications of LANDSAT data.

Now, however, we are able to report that we have at last commenced our long-projected land use interpretation and mapping study.

Initially our efforts in this field are being directed at an area known as the King Country. This area is delineated on the location map for the North Island included at the end of the report.

Dependent on the success of this exercise other major areas of New Zealand will be subjected to similar studies in the future.

CARTOGRAPHIC BRANCH

1.0 Preparations are under way to provide this Branch of the Department with the basic material required for a combined research/production project.

1.1 The project is aimed at revising and updating existing NZMS 18 series maps base data for use in the production of the new metric series of maps at 1:250,000 scale, namely NZMS 263 series.

1.2 Eight sheets are currently programmed for the project and progress will be reported in subsequent reports.

1.3 Continued success with the hillshading aspect of mapping is reported and an example of some of the work done thus far in the NZMS 262 mapping of the Nelson area of South Island is shown in Fig. 1 (see also South Island location map).

1.4 This type of product was achieved by use of the methods described in the Second Quarterly Report.

AERONAUTICAL CHARTING DIVISION

2.0 An example of similar work being produced by this Division is displayed in Fig. 2 (see also South Island location map).

2.1 This example forms a part of the hillshading base to be used in the NZMS 242 series 1:500,000 Aeronautical Chart No. 3 and highlights an area west of Christchurch.

2.2 The chart is compiled to meet International Civil Aviation

Organisation (I.C.A.O.) specifications and use of the imagery as an information source and the subsequent excellent relief depiction enable us to maintain the high standards required.

PLANNING AND INVENTORY DIVISION

3.0 Personnel in this division have made considerable progress since the second report. Under the leadership of Bob Child investigations are under way into the identification and delineation of land use categories employed in the composition of the NZMS 290 land inventory 1:100,000 scale series of maps. Fig. 3 shows the land use legend to be applied to this map series. The legend summarises the types of information we are attempting to extract from the imagery.

3.1 At this stage the above study is being carried out using 1:1,000,000 colour composited prints and 70 mm positive and negative material.

3.2 To facilitate rapid identification of research areas on the imagery, photo-reductions of basic mapping information, e.g. roads and hydrography, have been produced at the appropriate media scale.

3.3 The first trial of topographic data overlaid onto 1:1,000,000 imagery was carried out by constructing a clear positive film overlay from the 1:1,000,000 topographic map series. However, when the overlay and the imagery were used together in the colour isodensitometer the magnification factor used brought about considerable degradation of the original line work - effective but not completely satisfactory.

3.4 As a result it was decided to produce photo reductions from the topographic base of the 1:63360 series of maps scaled once again to fit into 1:1,000,000 imagery. This overlay is proving to be much more successful than the previous one as an aid in interpretation.

3.5 The next step will be to produce similar overlay material to fit the 70 mm products. Successful linework reproductions at this scale would lead to superimposition of topographic linework onto colour composited imagery via the colour additive viewer. This, we feel, would provide a considerable breakthrough in simplifying "eyeball" interpretation techniques.

3.6 Another aspect of the Planning and Inventory involvement concerns the use of the I²S camera system for satellite underflying. The camera is with the P.E.L. Remote Sensing Section as part of a joint evaluation programme of both camera systems and should be back in service shortly.

REMOTE SENSING WORKSHOP

4.0 At present the collection of ground truth data to be used when interpreting the imagery is carried out by suitably qualified members

of our field staff.

4.1 It was felt that these people should know why the information is necessary and how it is applied to the particular task in hand. To achieve this dissemination of knowledge, it was decided to hold a Departmental Remote Sensing Workshop.

4.2 The Workshop began by introducing the students to the difficulties encountered when producing a top quality land use map. This was handled by Bob Child, an expert in his particular cartographic discipline of Land Use Mapping.

4.3 The second stage consisted of instruction on the operation and application of the Bausch and Lomb Zoom Transferscope. General information on the application of the Zeiss Planicart E3 was also imparted to the students as a background to tests previously carried out, but they would not be directly concerned in its operation.

4.4 Next followed an introduction to the LANDSAT Project and its purpose. The various LANDSAT products were discussed along with the type of information to be expected from examination of each and suggested methods of application.

4.5 Lectures were given on the T²S Colour Additive Viewer and Colour Isodensitometer. Both types of multi spectral camera systems were discussed. The lecturer for the second stage was Doug Scott of the Remote Sensing Section, Department of Lands and Survey.

4.6 The third stage might well be described as a three hour "teach in". For this we had six speakers including two distinguished overseas experts, Dr Mike Duggin of C.S.I.R.O., Australia and Professor Tony Lewis of Louisiana State University, U.S.A.

4.7 Doug Scott began the "teach in" with a short dissertation on methods of interpretation and application of Colour I.R. film in the Nature Conservancy Council, U.K. Dr Peter Ellis of D.S.I.R. presented an overall picture of the LANDSAT Programme followed by Dr Ian Thomas (D.S.I.R.) relating methods of processing data received from EROS Data Centre. Dr Mike McDonnell then discussed computerised visual enhancement methods.

4.8 Dr Mike Duggin gave an account of remote sensing activities carried out by C.S.I.R.O., Australia and the lectures finished with Professor Tony Lewis setting forth his involvement with remote sensing in the United States of America.

4.9 As well as the students involved in the Workshop there were among the audience many other members of staff including the Director-General, Assistant Director-General and the Surveyor General.

4.11 Stage four was held at the D.S.I.R. Remote Sensing Laboratory and involved a "hands-on" practical approach to interpretation using the colour additive viewer and colour isodensitometer. This session turned out to be productive as well as instructive in that a considerable amount of constructive interpretation was carried out on our main study area, the King Country.

4.12 The Workshop proved of immense value to students and instructors alike. Many important lessons were learned on both sides which will be of great use in designing the format of our next Departmental Remote Sensing Workshop.

PHOTOGRAMMETRIC BRANCH

5.0 Trials have been carried out designed to evaluate the map revision potential of LANDSAT imagery at a plotting scale of 1:63,360.

5.1 Scene ID No. 2389-21172 of Feb 15th 1976, which encompasses the area to the West of Lake Taupo in the North Island, was used for these trials.

5.2 Monochrome transparencies of bands 6 and 7 at a scale of 1:1,000,000 were employed to provide the viewing model in the instrument.

5.3 Parts of NZMS 1 (1:63,360 scale) maps N 92, N 93, N 101 and N 102 were compiled to form a composite map of the area under test. This composite was used to provide plotting and scaling control within the instrument.

5.4 The Zeiss Planicart E3 plotting instrument linked to the EZ4 plotting table was again employed to good effect in this study.

5.5 Band 6 transparency was placed in the left hand carrier of the instrument and Band 7 in the right hand carrier and the whole operation carried out in a mono-viewing mode.

5.6 After relative orientation of the model, scaling was achieved by relating five identifiable points of detail on the model to the same five points of detail on the composite which had been positioned on the EZ4 plotting table.

5.7 An image to plot enlargement of x3.95 plus table gears of x2 plus the inbuilt x2 factor of the EZ4 table gave a final enlargement of x15.8; well within the scope of the instrument.

5.8 The scaling anomaly so obvious in para 5.7 arises as a product of two inconsistencies -

1. The transparency products received as part of the LANDSAT programme are not always as dimensionally accurate as might be hoped, and
2. The composite map had acquired an amount of differential expansion/contraction.

These inconsistencies were readily overcome by the Planicart.

5.9 Cronaflex UC4 tracing material was selected as the plotting medium, principally because of its dimensional stability.

5.10 During operation, water features such as lake shorelines, rivers, streams and ponds were plotted first as accurately as possible (this qualification is necessary because at the plotting scale of 1:63,360 the floating mark in the instrument optics measures 63.4 metres).

5.11 Small lakes, swamps and other areas subject to inundation, forest boundaries and felled areas were easily identified and plotted, but thereafter very little else was readily identifiable.

5.12 When the plotted detail was overlaid on the existing maps of the area, an excellent fit was achieved revealing areas worthy of revision in the next edition of the NZMS 1 map series.

5.13 Shortly after the aforementioned test was carried out we received from Dennis Fowler of D.S.I.R. Remote Sensing Section two colour composite transparencies at 1:1,000,000 scale.

EVALUATION OF COLOUR TRANSPARENCIES

5.14 Both transparencies had been constructed using bands 4, 5 and 7 of scene ID 2334-21123 adjacent to and east of the scene used in the previous test. Both were compiled by presenting band 4 in yellow, band 5 in magenta and band 7 in cyan.

5.15 In transparency (a) band 5 predominated giving an overall magenta cast while in transparency (b) the three bands were applied with equal intensity resulting in a pleasing predominantly orange/red hue overall.

5.16 Both the previous test and this were conducted by one of our most experienced photogrammetrists, Vic Harding, once more using the Planicart E3 plotting instrument.

5.17 Although not essential to the test since in essence it was to be of a qualitative rather than quantitative character, this instrument was used for the following reasons:

1. The illumination and optical viewing of diapositives is excellent.
2. It was the instrument used in all previous tests thereby providing consistency in optical and mechanical influences that might be introduced into the exercise.
3. The normal work programme had been arranged to allow for LANDSAT experiments.
4. Whereas the Bausch and Lomb Zoom Transferscope would have suited perfectly well in examining one transparency, the Planicart provided simultaneous viewing and assessment of both transparencies.

The transparencies were placed in the instrument as in the last test and a non stereoscopic model set up by the elimination of x and y parallax.

5.18 The viewing optics of the Planicart provide a x6 enlargement of the model and by comparing the information provided by the transparencies to the information presented on the relevant 1:63,360 scale map of the area, the following observations were noted:

1. The information presented on either one of the transparencies could be acquired to a degree from similar examination of monochrome transparencies but by presenting three bands together in different colours then interpretation was made easier and quicker.
2. Subtle changes in tone on monochrome were often difficult to spot but in colour the changes became instantly apparent.
3. Areas of erosion and scrub clearance which were not always obvious in monochrome seemed almost to leap out at the observer because of their strong green colouration as a result of this colour permutation.
4. Though set up in a non-stereoscopic mode nevertheless a false stereo effect was achieved because of the different photographic emulsion layers, plus the high quality transmitted light illumination of the transparencies. This aided boundary demarcation of vegetation considerably.
5. A similar effect came into play where rivers and streams were concerned. Areas of still water such as lakes and ponds were similarly enhanced.
6. Land sculpture was greatly enhanced by use of colour especially in area covered by bush and scrub.
7. In areas of strong colour, e.g. inundation, bush and erosion, roads and tracks were clearly defined, even insignificant ridge tracks showed through distinctly.
8. Whereas the indigenous forest is (in this test) of a red hue, exotic forest shows up as muddy red. This is the only vegetational difference highlighted at this stage. Further discrimination can readily be carried out but only as a result of information gained from ground truth surveys.

5.19 The purpose of this test was to assess the advantage gained in using colour composited transparencies as against monochrome material in terms of small scale mapping, i.e. 1:63,360 and smaller.

5.20 There is no doubt whatsoever that colour transparencies are superior both in the information to be extracted and in ease of viewing, the latter point is as important as the former because this type of work will be carried out in practice by "eyeball" methods.

5.21 The point that emerges above all others is that the maximum

interpretation return can be achieved only when the interpreter has good ground truth knowledge of the area under scrutiny. This applies particularly in terms of vegetational discrimination.

5.22 The next move will be to obtain a variety of colour composited transparencies of the same area for assessment so that the various colour permutations can be evaluated in terms of interpretation and mapping.

IMAGERY PLOTTING

5.23 Paragraphs 4.9 - 4.14 of our part of the Second Quarterly Report describe tests carried out at scales of 1:250,000 and 1:25,000 using the Planicart and LANDSAT imagery.

Figure 6 and 7 in this report present in graphic form some of the results obtained in these tests.

5.24 Fig. 6 presents a 1:250,000 plot of the Marlborough Sounds area of South Island. Briefly the procedure followed was that ground control for the area was plotted onto Cronaflex UC4 draughting film using the EZ4 plotting table as a co-ordinatorgraph.

5.25 After intensive study of the imagery six of these ground points were identified with certainty (shown on Fig. 6 by two concentric circles and a centre cross). These points were used for scaling the imagery to the plot.

5.26 Single circles with centre crosses represent ground control which was thought to have been identified but with an element of doubt.

5.27 Single circles with centre dot signify unidentified ground control.

5.28 After scaling the coastal outline was plotted and compared favourably with existing map work of the area. The control points with doubtful identification were then plotted in the position as interpreted by the operator through the instrument.

5.29 The operator managed to correctly relate nine points on the imagery with their plotted co-ordinate values (annotated ND on plot). Twenty six other points were identified and plotted, they are shown with vector arrows and spatial difference in millimetres. The previously unidentified points remained unidentified.

5.30 It is obvious that the main problem is the identification or interpretation of ground control on the imagery. Various methods have been tried to overcome this difficulty but the general consensus of opinion is that the answer lies in our Reflector Programme.

5.31 Fig. 7 presents a part of the plot resulting from the test described in paragraphs 4.10 to 4.14 in our contribution to the Second Quarterly Report.

5.32 The plot clearly demonstrates the following:

- (a) The high orthomorphic quality under controlled conditions inherent in the imagery.
- (b) The quality of the Zeiss Planicart E3 plotting instrument.
- (c) The skill of the operator (Vic Harding).

Once again it is worth noting that the floating mark in the instrument has a scale diameter of 63.4 metres.

CARTOGRAPHIC REFLECTOR

6.0 The MKI system was constructed to accommodate the intended overpass at Burnt Hill, near Darfield during April 1976. This attempt, however, was negated by 10/10ths cloud cover.

6.1 To allow the reflector to be used anywhere in New Zealand modifications were made to the alignment device giving greater flexibility to alignment.

6.2 In the MKII the main body of the alignment device has been modified at its base resulting in a considerable amount of fore and aft movement about a pair of hinge posts.

6.3 At the top of the device a rotatable alidade and specially designed protractor have been added. See Figs 4 and 5.

6.4 Since the Darfield attempt we have had a further three attempts at "shooting" the satellite but due to adverse weather conditions all to no avail.

6.5 The present reflector site is at the Auroral Station based near Lauder in Central Otago, 45.04°S 169.69°E.

ANTARCTIC MAPPING

7.0 The projected mapping of Antarctic regions from LANDSAT data has not yet gone beyond the conceptual thinking stage due mainly to the arrival in New Zealand of three maps of the Antarctic prepared by U.S.G.S.

7.1 These maps have been compiled from LANDSAT imagery and are currently undergoing evaluation. The aim of the evaluation is simply that if these maps, as produced by U.S.G.S., fulfil all the mapping requirements of New Zealand's interest in the Antarctic then it would be wasteful to duplicate what has been done elsewhere.

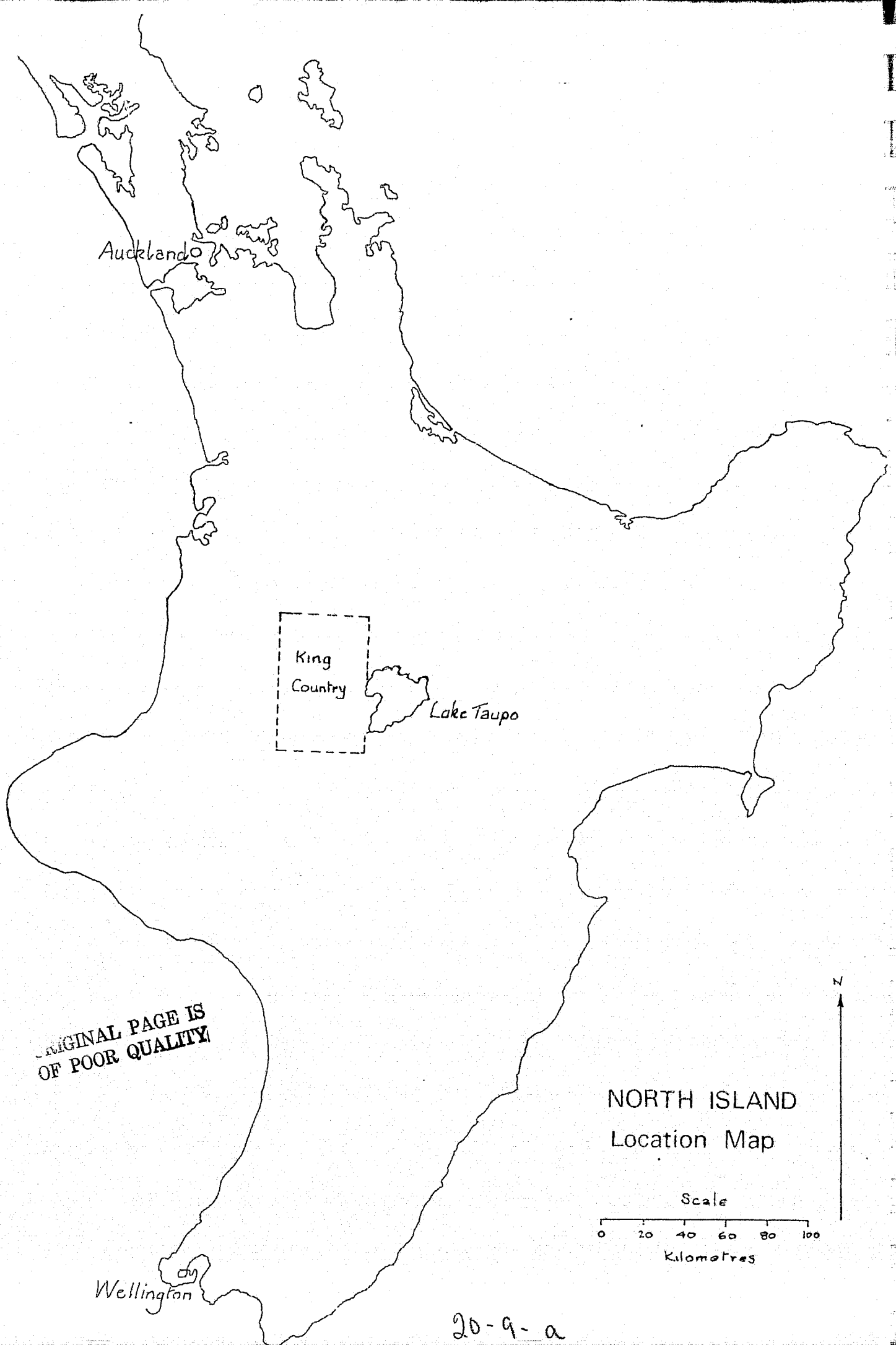
7.2 Preliminary investigatory probes into snow, ice and geological

features as presented on the imagery make it clear that said imagery has much to offer in extending present knowledge of the area. This study will proceed regardless of the mapping programme.

CONCLUSION

8.0 Once again we go on record in expressing our thanks to the D.S.I.R., Physics and Engineering Remote Sensing team for their continued excellent service, advice and assistance.

8.1 Within the Department of Lands and Survey more and more of staff are becoming aware of the potential of LANDSAT and more people are becoming involved.

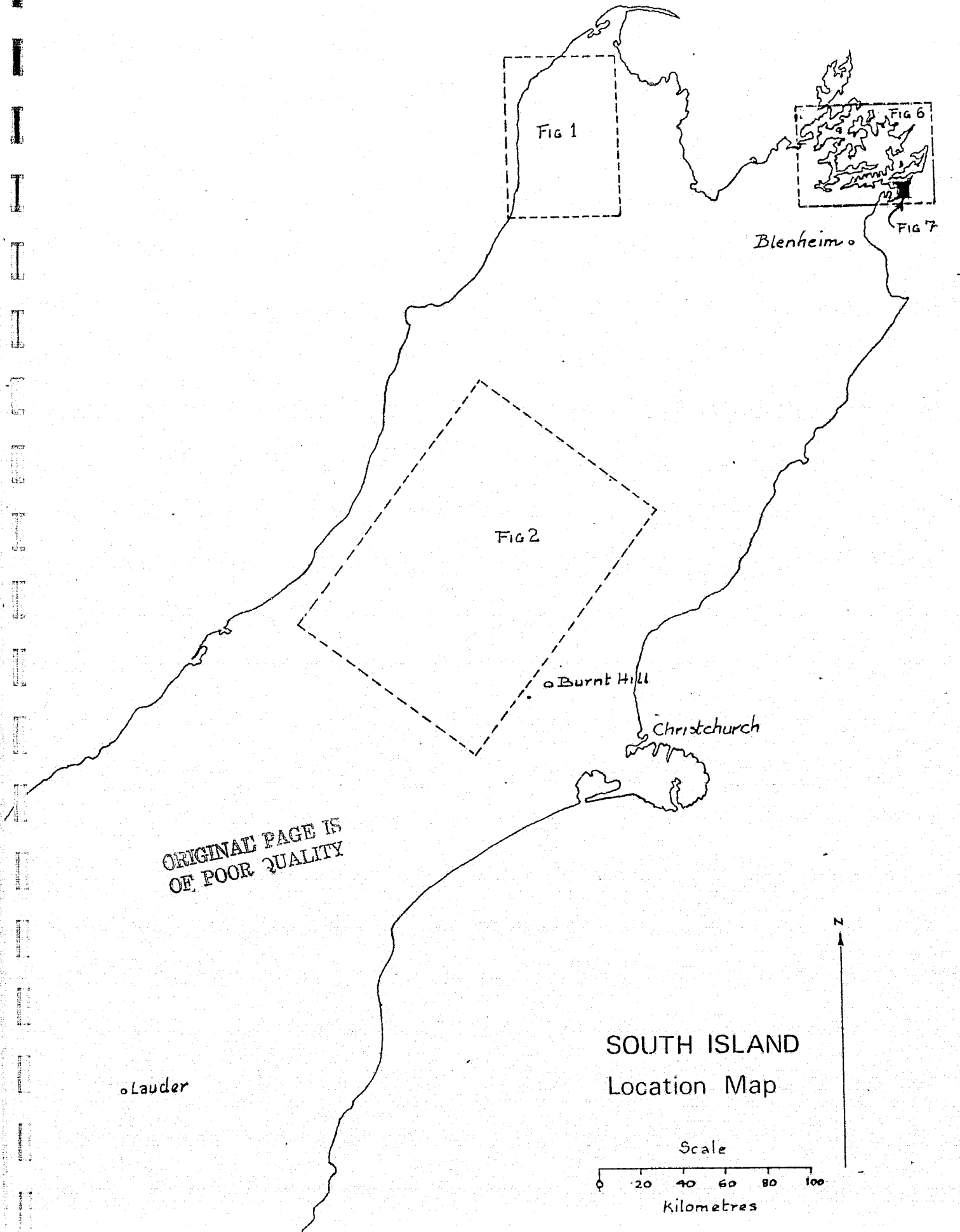


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NORTH ISLAND
Location Map

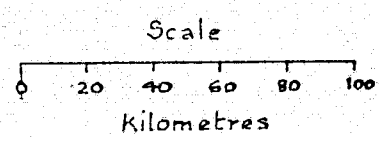
Scale
0 20 40 60 80 100
Kilometres

20-9-a

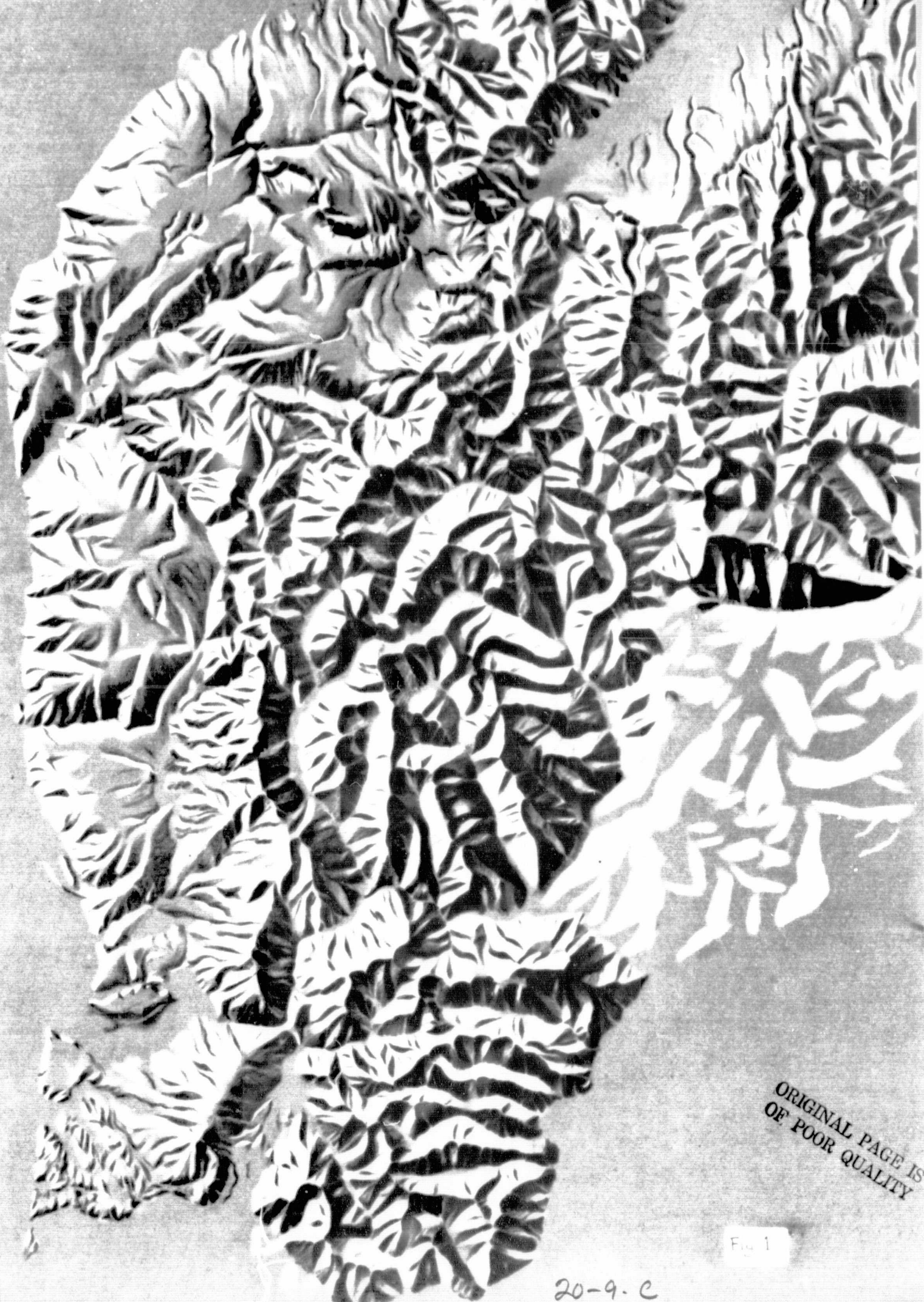


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SOUTH ISLAND Location Map




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Fig 1

20-9-C



Part NZMS 242
Sheet 3
1:500,000

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LAND USE MAP LEGEND

NATURAL AREAS

Codes in UNIVERS 56 10pt

Wildlands

pencil no 8733

Steeplands	s
Uplands	u
Downlands	d
Lowlands inland	l
Lowlands coastal	c



Resource conservation areas

pencil no 8743

Water	h
Soil	p
Vegetation	v
Wildlife	w
Recreation	r
Special purpose	z

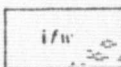
Wetlands and floodplains

pencil no 8753

Water	man made	natural	m/n
Floodplains			f
Wetlands			a
Tidal flats			
Mangrove			
			Bogs, marsh swamps, etc

NOTE: Compound codes indicate the land is used for multiple purposes and activities
... colour indicates predominant use

eg The land is predominantly grassland, but is a flood-plain with some waste and marsh




PRIMARY INDUSTRY

Codes in UNIVERS 67 10pt

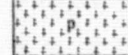
Farming

pencil no 8739

Specialist livestock	l
Market gardens and Orchards	g
Arable farming	a
Dairying	d
Grassland farming undeveloped/improved	i
developed/ sown	s
Farm Woodlots	w
Honey production	h
spring	h
autumn	h
summer	h
winter	h
Marine	

Forestry

pencil no 8738

Plantation cleared for planting	p
planted	
Timber	t
> 1/3 removed	t
1/3 - 2/3 "	t
< 2/3 "	t
Timber reserve, virgin	v
cutover	c

Extractive

pencil no 8738

Quarrying	q
Mining	u
Dredging and sluicing	e

OTHER AREAS

Codes in CONCORDE 10pt

Rural institutional

pencil no 8727

Historical	h
Amenity	a
Special Institutional	name

Urban

pencil no 8748

Built-up	u
Open space	p
Institutional and functional	f

Idle land

pencil no 8737

Waste	w
Derelict	d
Idle	i

SYMBOLS for isolated features or areas of less than 20 hectares

Sawmill	
Dairy factory	
Isolated mine	
" quarry	
" dredgings	
Historical site	
Tourist "	

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Fig 3

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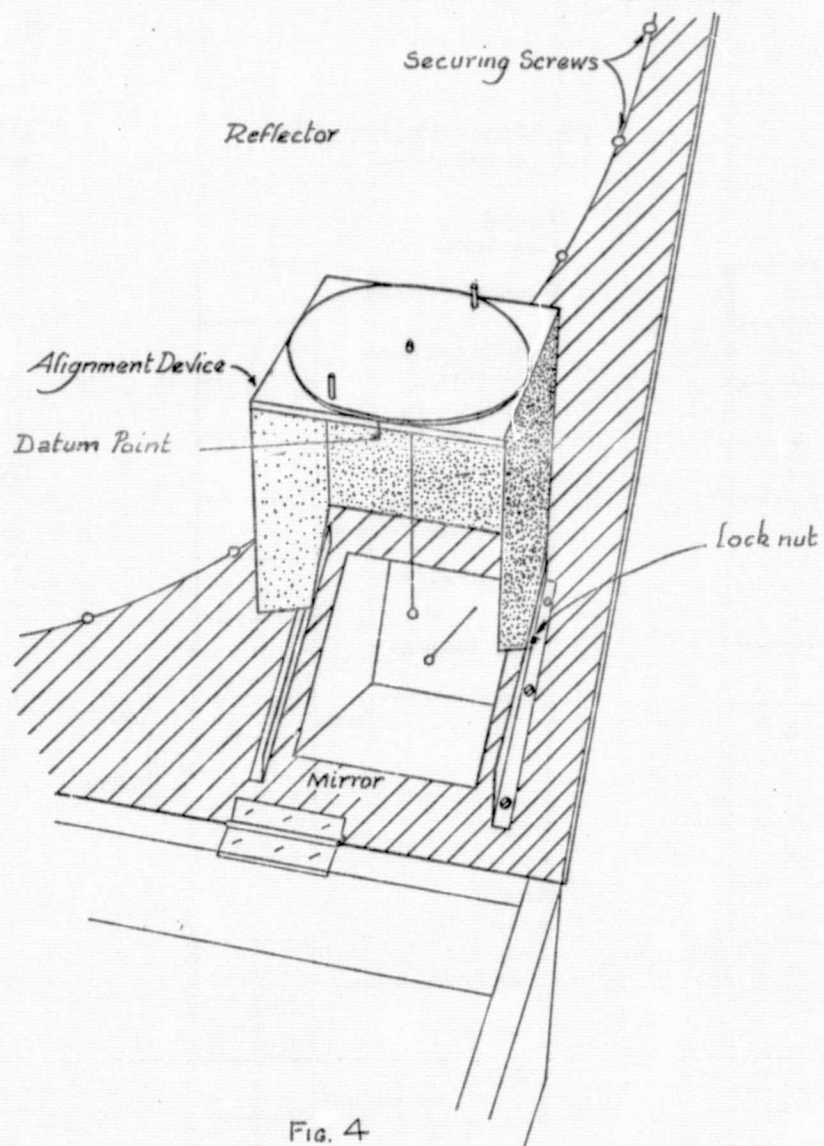
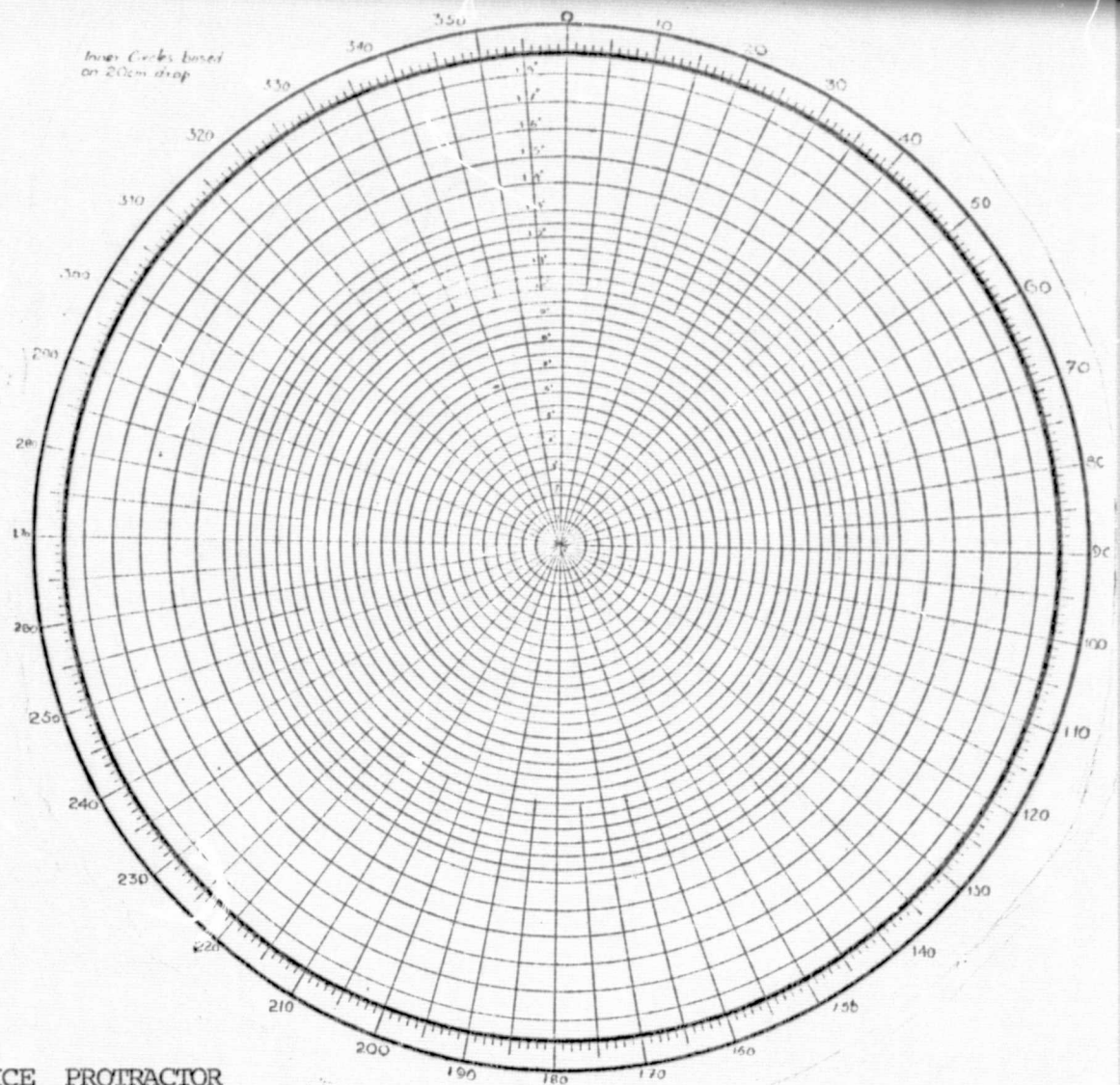


Fig. 4



ALIGNMENT DEVICE PROTRACTOR

The protractor illustrated was co-designed and constructed by Land and Survey and DSIR with simplicity of operation and accuracy as its prime requirements.

The Protractor, constructed from matt finish draughting film, is sandwiched between the 6 mm clear perspex top of the main body and the 6 mm clear perspex alidade disc. Both alidade disc and protractor disc are centre drilled to permit rotation about a common axis anchored to the body top.

The axis port is also drilled to above diameter sufficient to allow a strong thread to be passed through the box and one end secured to the top of the port.

A weighted ball is attached to the free swinging lower end of the thread at a distance of 20 cms between the protractor disc and the ball centre.

The graduations and intercepts on the protractor have been designed so that a trained technician on site can set the device to assume a pre-calculated intercept position when the pendulum shadow is cast up onto the protractor via the reflected sun rays through the angled base mirror.

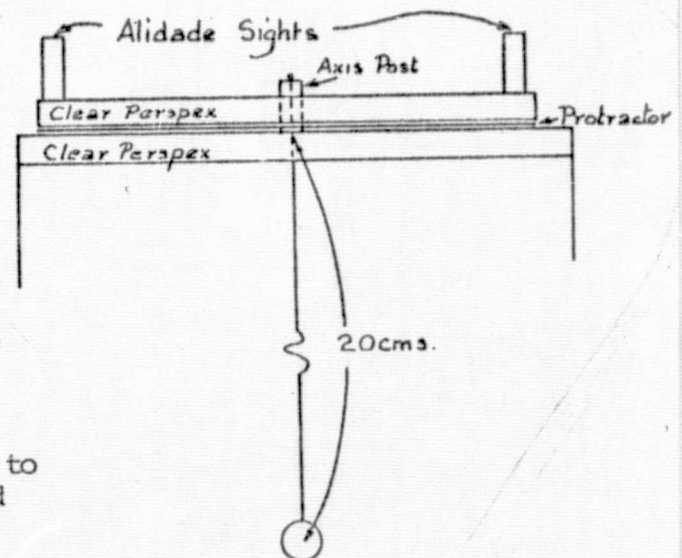
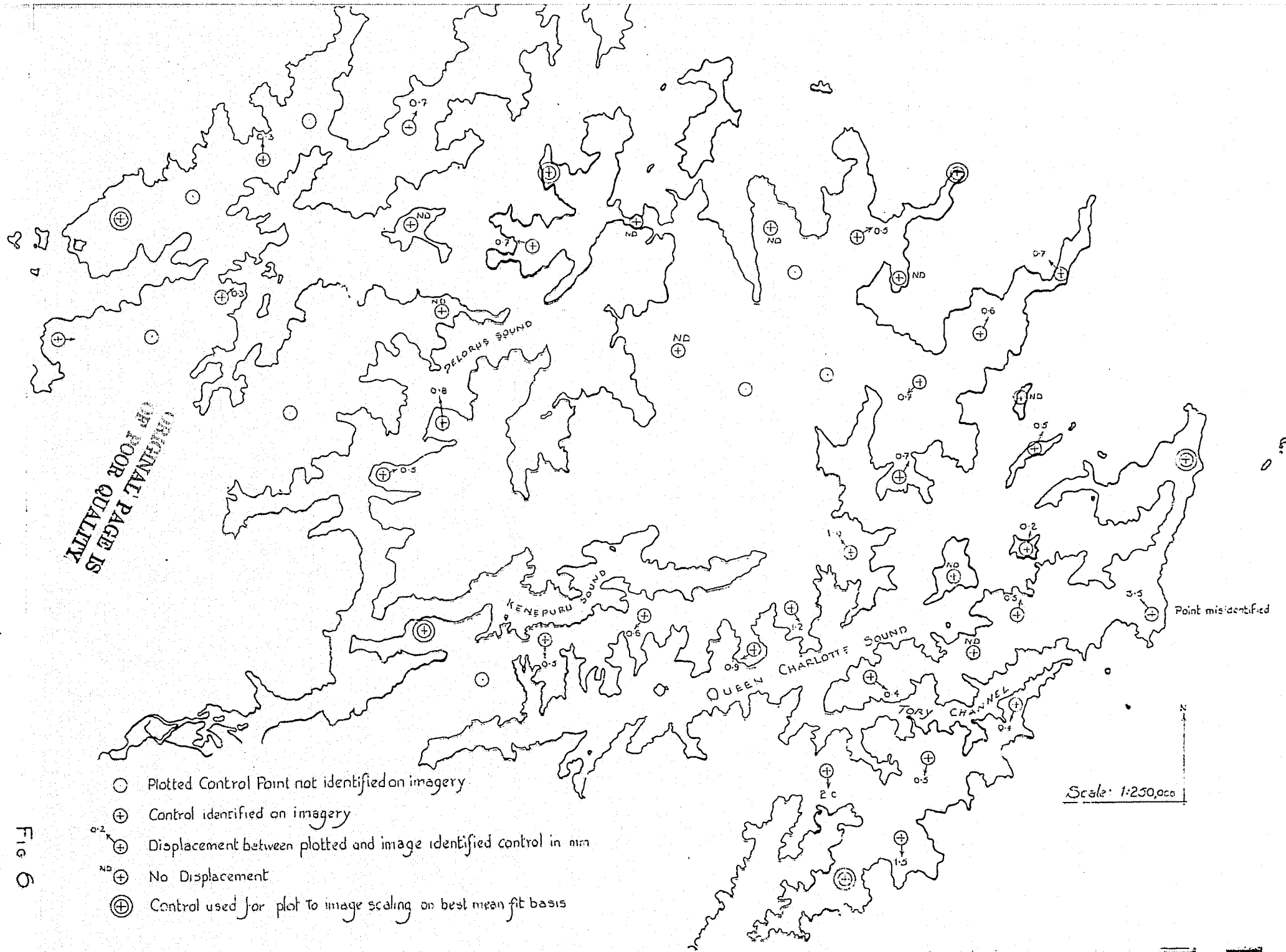


FIG 5

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- Plotted Control Point not identified on imagery
- ⊕ Control identified on imagery
- ⊕_{0.2} Displacement between plotted and image identified control in mm
- ⊕_{ND} No Displacement
- ⊕⊕ Control used for plot to image scaling on best mean fit basis

FIG 6

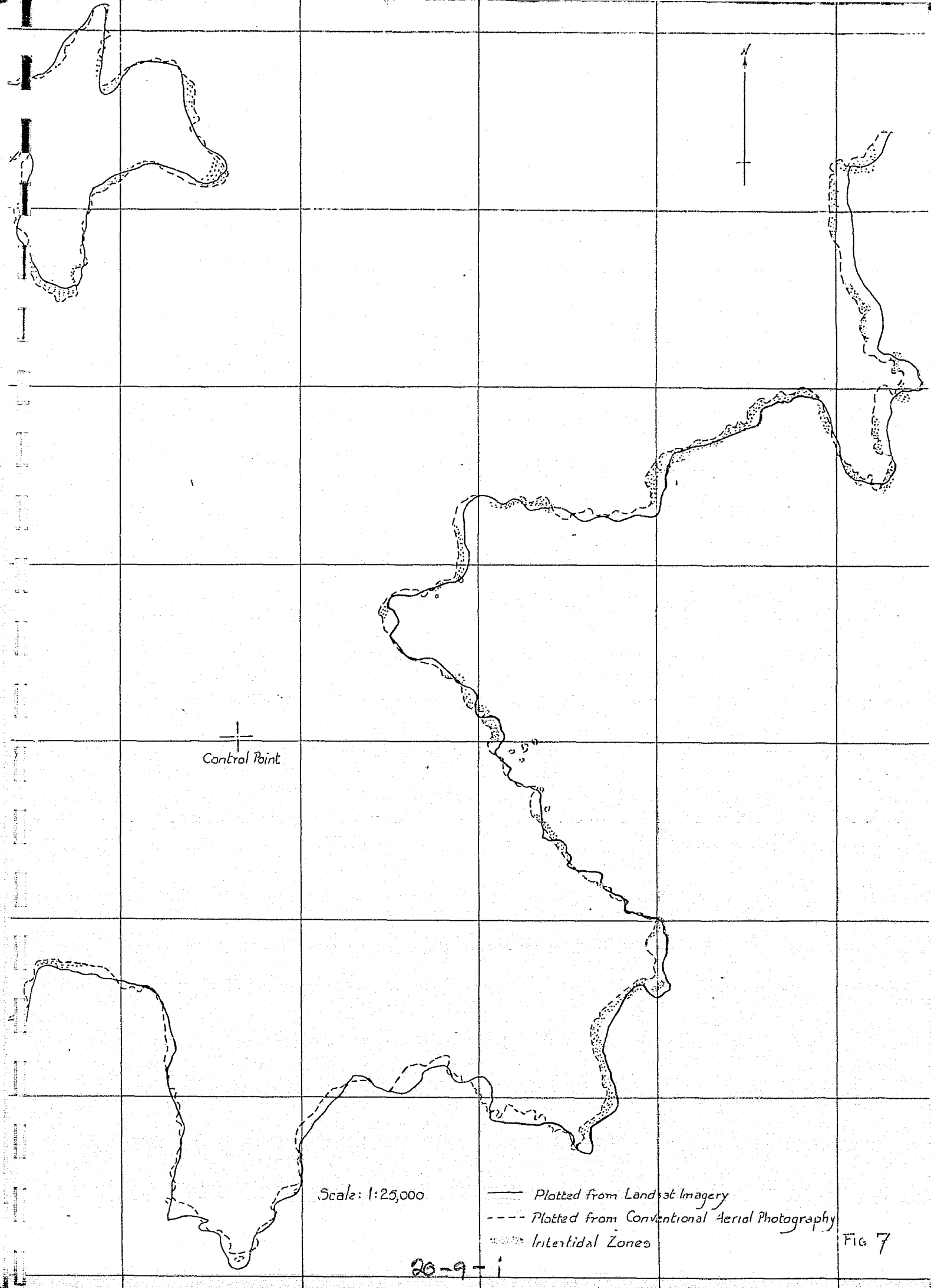


FIG 7

PART V

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LANDSAT PROJECTS

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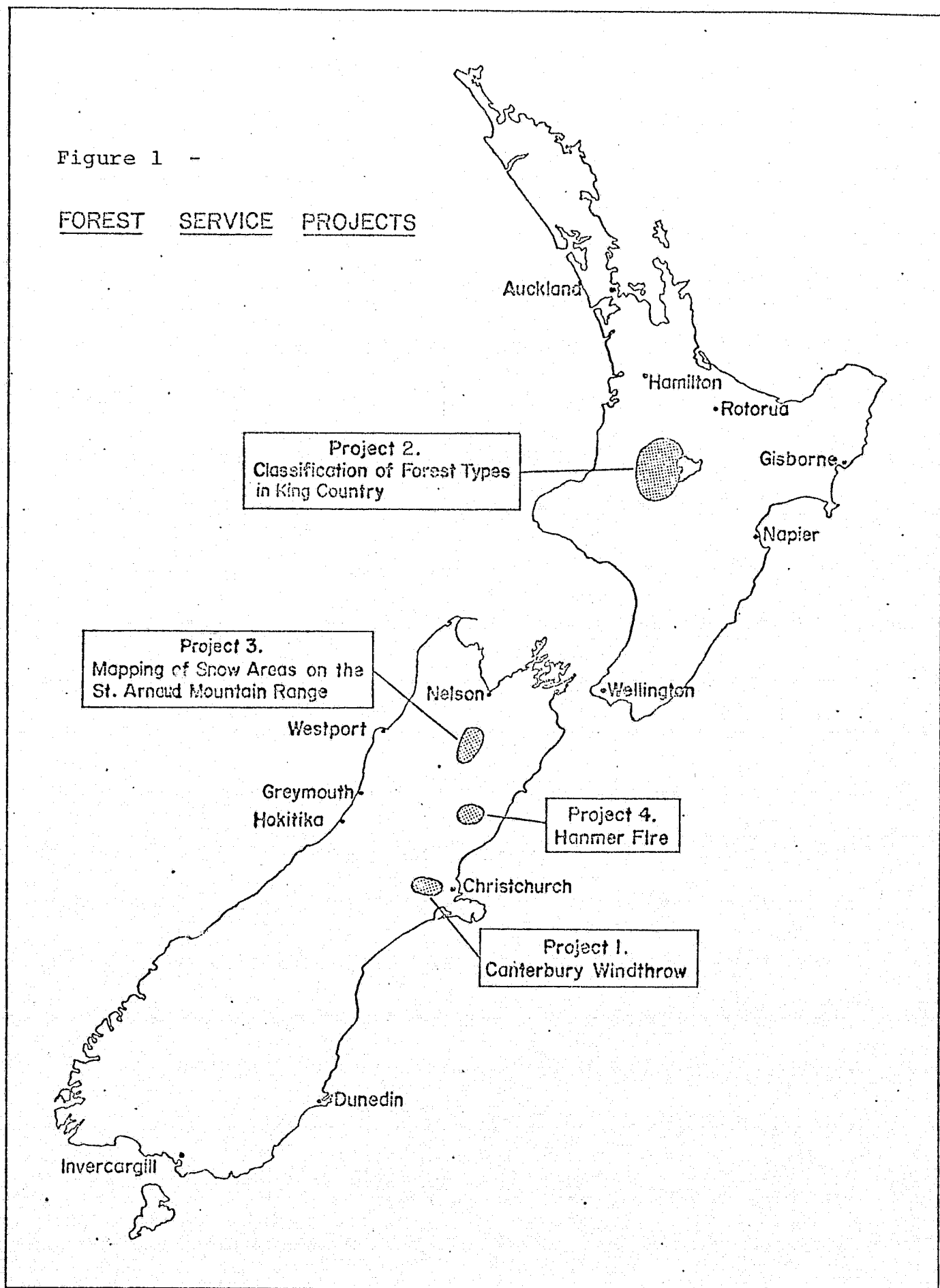
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|--------------|---|---|
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| Dark Blue | - | denser forest canopy (generally podocarp) |
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- | | | |
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| Band 5 | negative | printed through red filter |
| Band 7 | negative | printed through green filter |
- This resulted in the snow appearing as a reddish colour.
- Figure 6 Colour isodensitometer coding of density levels from Band 4 positive transparency of the 2282-21252 scene recorded on 31 October 1975. The snow areas are suggested as occupying the yellow and purple region along the ridge tops. Differentiation between snow and high country tussock, exposed rock etc. will only be apparent by analysing this isodensitometric data in conjunction with MSS additive imagery similar to Figure 5(b).

Figure 1 -

FOREST SERVICE PROJECTS



1. CANTERBURY WINDTHROW - Mr N. Ching (NZFS, Wellington)
Eyrewell State Forest

1.1 Interpretation

Following the last quarterly report (PEL No. 531) the interpretative imagery produced by PEL from the CCT products has been the subject of a detailed interpretation by Mr Brian Lean, N.Z. Forest Service, Christchurch. He has used his local knowledge and, 1:10,000, stereo aerial photography to interpret the 31 October 1975 computer generated colour composite as shown in Fig. 11 of the last quarterly report. From the material Mr Lean has produced the "ground truth" type map shown in figure 2.

The recorded imagery was influenced by such factors as: crown density, recent thinnings to waste, recent logging, vigour of grass coverage, any clearing or site preparation of surface soil in recent years.

From this initial interpretation, the following conclusions have been drawn:

- Windthrow effected mainly 1965 (10 year old) and older *Pinus radiata*.
- Recent plantings would be dominated by the soil reflectance, i.e.
 - + 30% crown cover is mainly 1970-73 *Pinus radiata*
 - + 50% crown cover is mainly 1969 *Pinus radiata*
 - + 60%)
 - + 75%) crown cover is mainly 1966-68 *Pinus radiata*
- For older *Pinus radiata* the crown density and hence detected reflectivity would be affected by survival rate and treatments, i.e. inter planting of like or different species. In still older crops by thinnings.

For the final result it is planned to consider more carefully the previous treatments.

1.2 Desiccation of Windthrown Trees

Since the imagery has located the windthrown trees, plans are being drawn up to ascertain if the rate of desiccation can be measured. Local knowledge has predicted that the trees are likely to deteriorate considerably over the coming summer period. Imagery has been requested during the period before and directly after summer (September - November 1976 and February - April 1977). Such imagery will give an almost unique opportunity to evaluate its applicability to monitoring desiccation in windthrown timber.

1.3 General Comments

For disaster areas, such as Canterbury windthrow, imagery and CCTs must be made available immediately to gain maximum benefit. Obviously this would only be gained if New Zealand obtained a receiving station.

2. CLASSIFICATION OF FOREST TYPES IN THE KING COUNTRY - Mr R. Dale (NZFS, Auckland)

The use of colour composite photographs and density scans for identifying forest categories on the basis of species composition and canopy structure were evaluated for the current King Country Land Use study. The Forest Service's role in this multi disciplinary land use study, involving several other Government agencies and local authorities, is to assess the study area's potential for exotic and indigenous management. To assess forest conditions and regeneration potential, it is necessary to identify each forest type and sample by ground survey parties. Original type maps were prepared in the late 1950's. Extensive forest modification has occurred in these forests - with the exception of certain protected areas, much of the area has been converted to pasture, exotic forest or left in a cutover condition.

No recent forest typing of the area has been undertaken and this exercise was initiated to evaluate the use of multispectral satellite photography in indigenous forest typing.

Two basic techniques were evaluated at D.S.I.R.

A. Colour Additive Viewer

B. Iso-Densitometer

A. Colour Additive Viewer

Initially results from this process were disappointing because of poor colour balancing. However, subsequent results are more promising as seen in figure 3. This figure is an enlargement of scene number 2389-21172 recorded on 15 Feb 1976. The original negatives were enlarged and photographically dynamically enhanced by the PEL Photographic Section and colour combined using the usual additive balances of Band 4 Blue, Band 5 Green and Band 7 Red (in colour negative form) by the PEL Remote Sensing Section.

For vegetation typing purposes:

(a) Forest types can be identified with a good deal of certainty, e.g.

(i) recently converted cutover is easily distinguished in figure 3 as blue

- (ii) high altitude scrub types are identifiable as a lighter shade of red
- (iii) unlogged podocarp forest appears as almost black
- (b) On a regional or national basis the technique would be valuable for monitoring changes in the indigenous forest area, say on a year to year basis. Losses to exotic conversion, agricultural production would be readily apparent.
- (c) Enlargements at a scale of 1:100,000 are being prepared. If sufficient definition is available at this scale they could prove of value in forest typing exercises.
- (d) However, much of our forest management zonation exercises involve identification of small forest areas forming a mosaic of forest types, and often involving a good deal of variability between individual forest associations. Further investigation and correlation of LANDSAT II material with well typed forest areas is necessary before valid conclusions on its value for this form of exercise can be drawn.

B. Iso-Densitometer Images

1. Positive transparencies of a single spectral band were viewed on the colour coding density enhancing densitometer and the image viewed on the colour television tube. Simple colour slides were taken using a normal 35 mm Pentax camera mounted on a tripod approximately 1½ metres from the screen. An example of this technique is shown in figure 4. This figure portrays the density variations in band 6 of part of scene number 2389-21172 taken on 15 Feb 1976. This section of Pureora State Forest is coded thus:

Yellow	- hardwood scrub
Dark Blue	- denser forest canopy (generally podocarp)
Lighter Blue	- hardwoods (probably tawa)
Clear	- grassland and recent cutover conversion

2. The video camera was adjusted to maximum magnification (giving a scale on the tube of approximately 1:80,000) and the entire King Country Land Use study area was photographed in this manner. A grid was superimposed to allow easy identification of each slide.

3. It was intended to project the slides onto a topographic base map of approximately 1:63,000 scale and then transfer type boundaries onto the base map for comparison with existing type map data and conventional aerial photographs.
4. However, distortion from errors in positioning of the camera, screen curvature and lens distortion from both the video camera and the slide camera was greater than expected and it became difficult to register forest type boundaries with topographical features.
5. It is planned to use fine topographic overlay (reduced photographically to the same scale as the transparency) to enable a more accurate registration to be effected. The use of a rectangular grid would allow the degree of distortion to be determined from the T.V. camera lens to the final projection onto screen.
6. Scrub, high forest and cutover were easily identified from the slides. Colour prints were prepared from these slides but the degree of colour differentiation has been lost in the colour printing process.
7. Unknowns - i.e. topography, sub-canopy species, underlying geology and soil types, drainage, all appear to influence the forest type pattern.

Further work is required to correlate forest types on the ground with colour combinations produced and to compensate for these additional factors.

3. MAPPING OF SNOW AREAS ON THE ST. ARNAUD MOUNTAIN RANGE - Mr R. Hodder (NZFS, Wellington)

LANDSAT imagery is being proposed for mapping the snow cover on the St. Arnaud Mountain Range to determine its suitability for a ski field. The St. Arnaud Range, situated 172°50' E 41°52' S, rises to an altitude of 6100 ft above mean sea level and separates the Nelson Lakes National Park from the Rainbow State Forest.

The present Mount Robert Skifield situated to the west of the St. Arnaud Range on Robert Ridge, within the Nelson Lakes National Park, has variable snow conditions for a relatively short winter season. This is because of its altitude (4500 ft) and northerly aspect. Its further development is constrained by the requirement for vehicle access to the ski tows and the moderate to easy topography of the area serviced by ski tows. Road access would, of necessity, traverse a steep eroding face that is visible from intensively used areas of the Park and from a State Highway.

Because of the limitations of this Mount Robert skifield the Nelson Lakes National Park Board sees the need for the development of an alternative skifield within the area and have sought help from the N.Z. Forest Service and the Department of Lands and Survey.

The high capital investment involved in the development of new skifields requires that historic patterns of snow fall, characteristics of snow, assessment of climatic factors associated with human safety and comfort, and the practicality of access, be considered.

The use of LANDSAT imagery showing snow cover of the two adjacent ridge systems - Robert Ridge, St. Arnaud Range - complemented by ground truth studies and assessment of topography, will substantially shorten the investigation period.

Aerial and ground investigations of the St. Arnaud Range confirm that there exists several areas of suitable size, topography, and altitude, suitable vehicle access routes, for development into a skifield.

The LANDSAT II image of 31 Oct 75, shown in Figure 5, shows that a distinction can be made between snow cover, alpine grasslands, snow shadow zones* and, in the absence of ground truth data, some evidence of graduations in snow cover also seem to be apparent. Such information will be transferred to a 1:25,000 topographic map in this initial evaluation exercise and will form a base for future studies with LANDSAT imagery. This colour composite imagery will be supplemented by contour data extracted from colour isodensitometer images such as Figure 6.

If sufficient images can be obtained in future seasons, especially at the beginning and end of the winter (April - June, August - October), they would enable assessment of snow cover, depth and possible other characteristics from LANDSAT imagery to be correlated with ground measurements. Such an evaluation study would also assist other departments concerned with using the imagery in assessing its uses in calculating hydro-electric power potential and possible irrigation yields.

Ground Truth

Of several basins in the St. Arnaud Range the "Six Mile" Creek headwaters appear initially to have the most potential. This initial LANDSAT imagery has assisted in the choice of suitable ground truth sites. Ground truth standards will therefore be established in this basin and, for historic comparison, in the area of the Mount Robert ski field. Measurements will be made spanning the time of the predicted LANDSAT spanning overpasses to determine:

1. Snow distribution

- total cover
- partial blanket
- patch snow
- ice
- water (tarns)

* A snow shadow zone is that area shaded from direct sunlight by bluffs etc., and which could lead to the formation of icy snow conditions.

2. Distribution of

(i) vegetation above forest line

- short tussock
- long tussock
- scrub cover

(ii) rock areas

3. Snow Depth and Characteristics

- <10 cm
- 10 - 20 cm
- + 20 cm

and whether:

- powder
- granular.

4. Shadow Zones

Based on the 31 Oct 75 imagery, a Transect line will be established across the topography of the basin and the above features determined for a distance of 100 metres either side of the line. Controls for location would be established along the Transect line.

4. HANMER FIRE - Mr N. Ching (NZFS, Wellington)

On 22 and 23 of March 1976 a fire burnt some 537 hectares of exotic forest. Approximately 200 hectares were completely burnt and defoliated. Of the remaining area, 180 hectares was burnt leaving scorched foliage and 157 hectares burnt with green foliage.

It is proposed to attempt to detect any change in vigour, in the scorched and green foliage using:

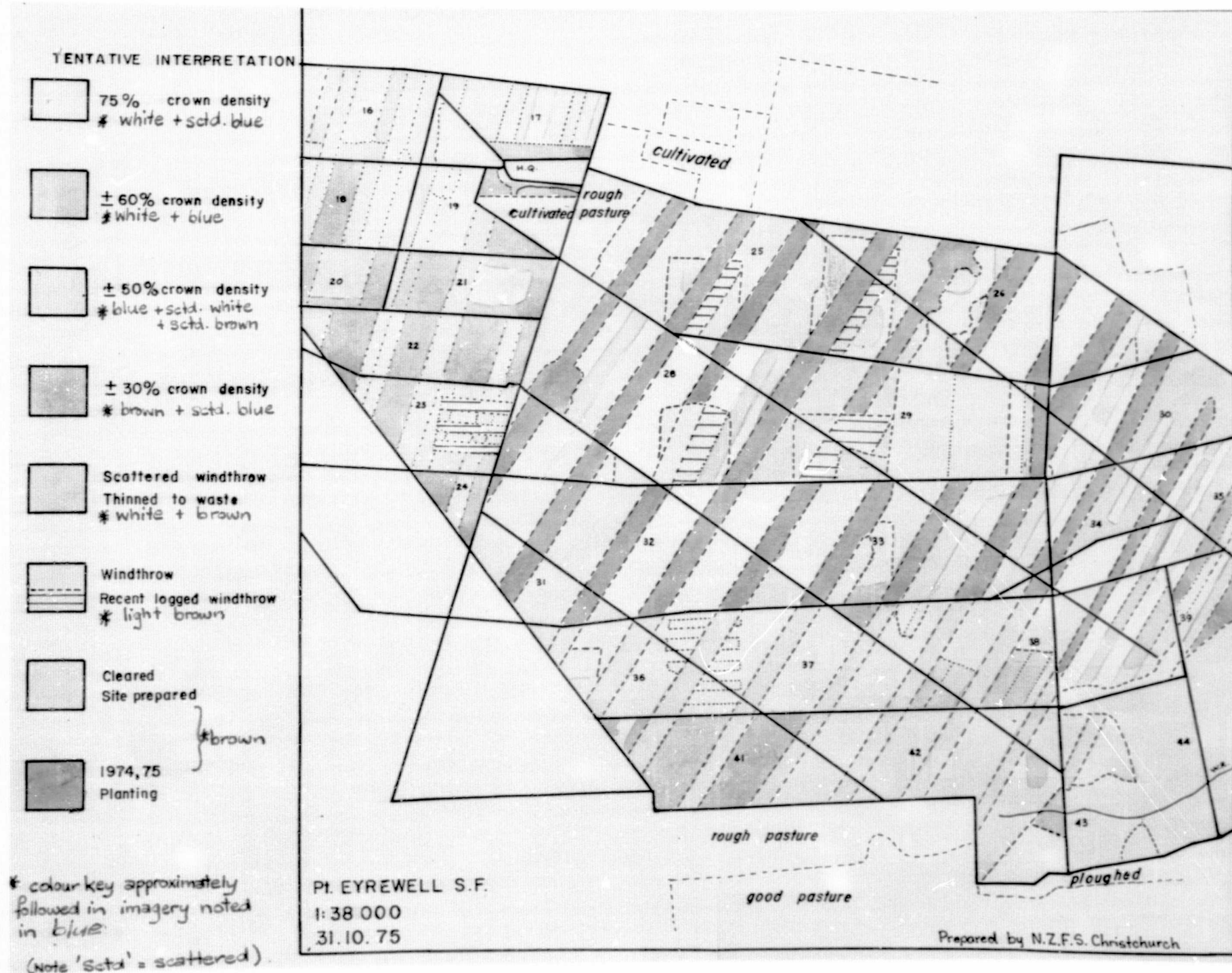
1. LANDSAT imagery
2. Underflying with the PEL multi-spectral Hasselblad camera system.
3. Underfly with Kodak 2424 black and white infrared film using a N.Z. Forest Service Hasselblad.

LANDSAT imagery will be required in late November 1976, after the spring growth, and again after this summer (February 1977) and the following summer (February 1978).

Underflying will be attempted on the same day as the satellite overpass.

Figure 2

The colour coded result of an interpretation of the enhanced image of the Eyrewell State Forest which was Figure 11 in Part I of our Second Quarterly Report.



21-6-a

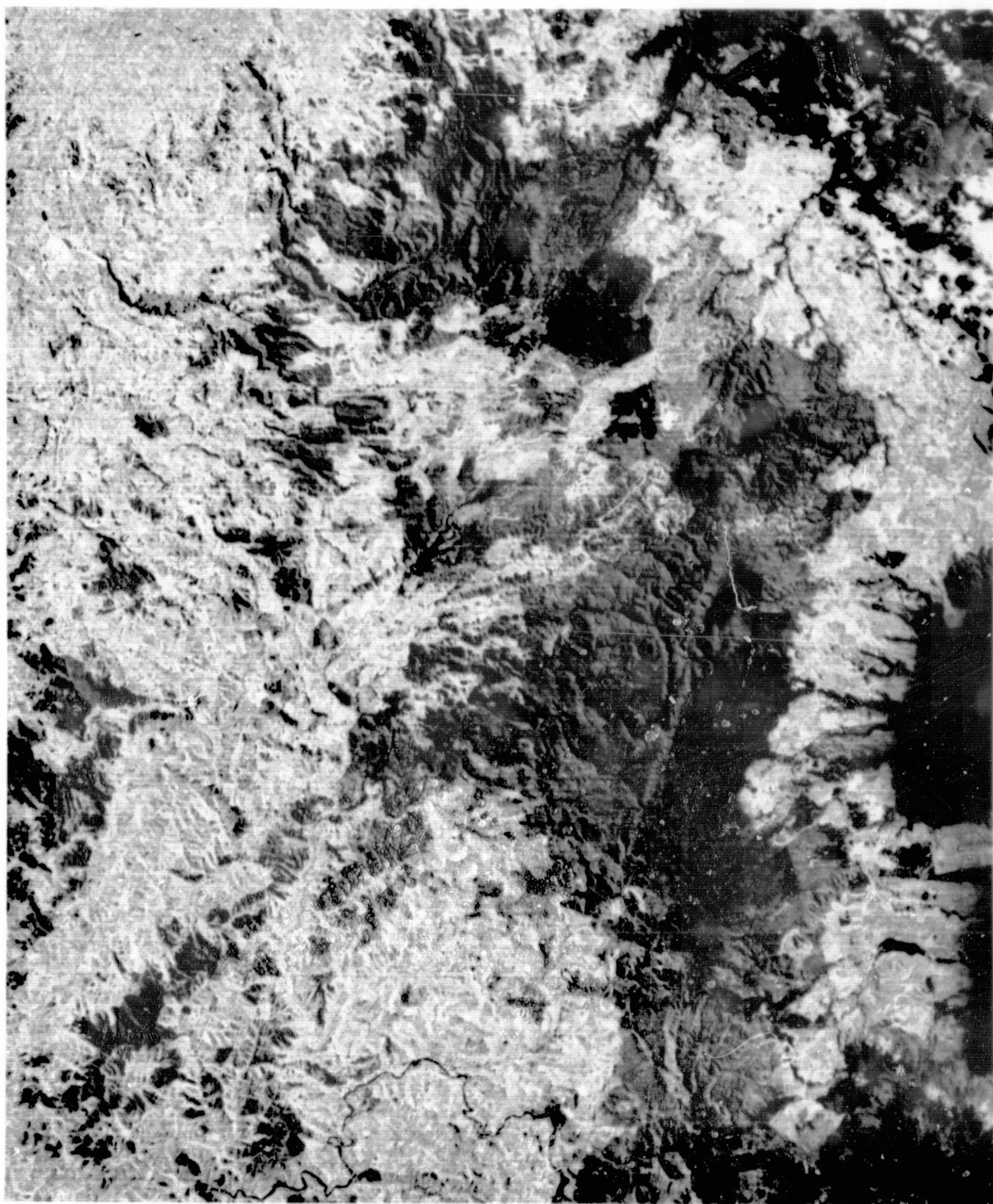


Figure 3 An enlargement of the 15 Feb 1976 LANDSAT II image 2389-21172 of the King Country area produced on the colour additive viewer (see text).

21-6-B

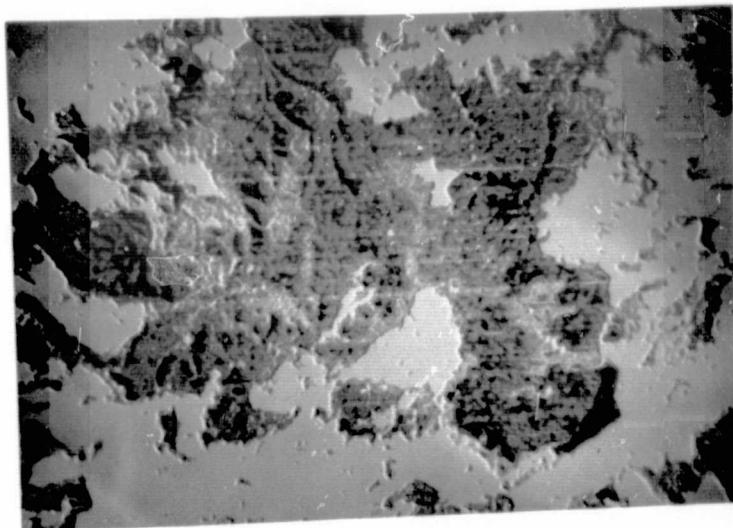


Figure 4

An enlargement of the 15 Feb 1976 LANDSAT II image 2389-21172, produced on the colour isodensitometer and showing part of the Pureora State Forest coded as

- | | | |
|--------------|---|---|
| Yellow | - | hardwood scrub |
| Dark Blue | - | denser forest canopy (generally podocarp) |
| Lighter Blue | - | hardwoods (probably tawa) |
| Clear | - | grassland and recent cutover conversion |

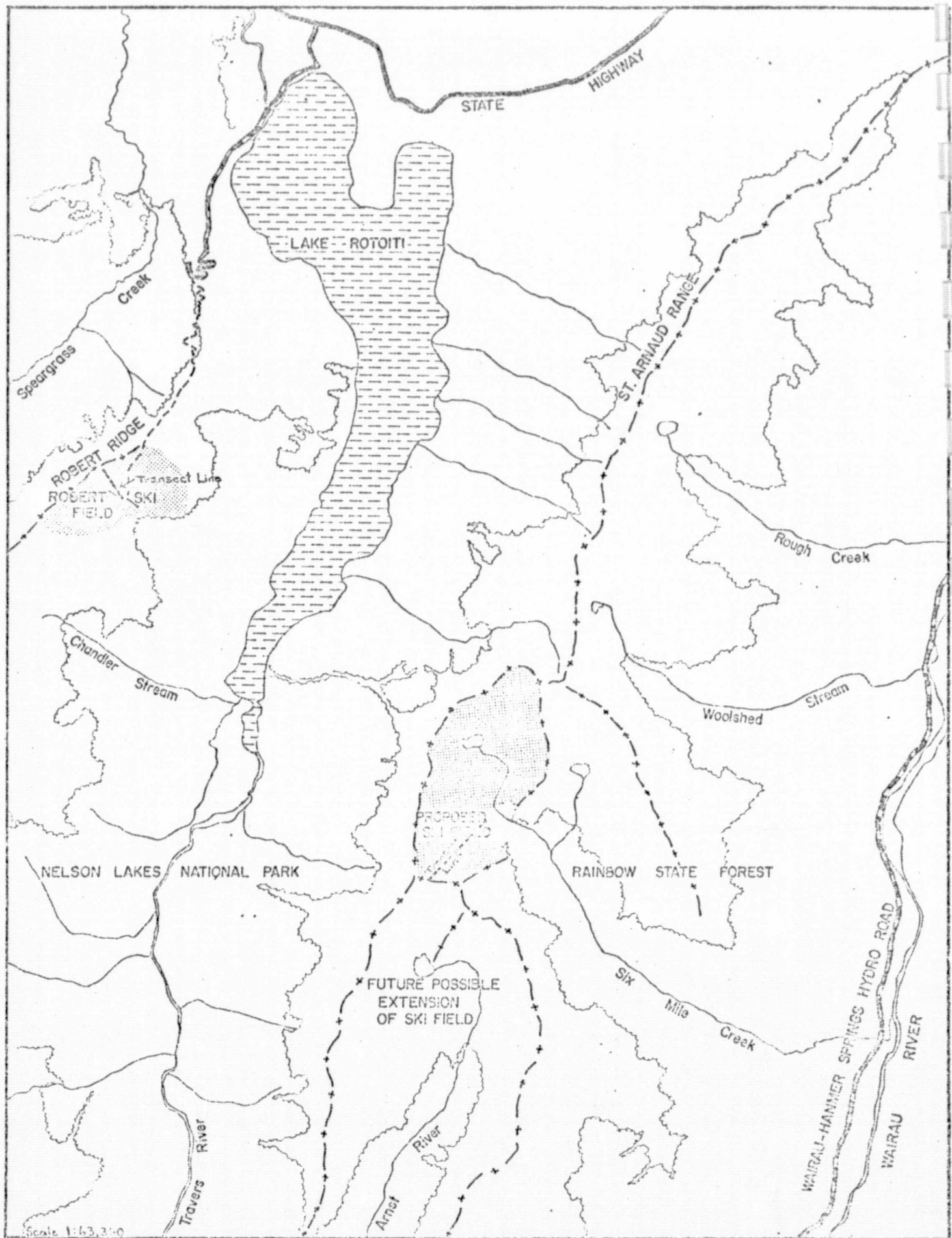


Figure 5(a) Ground feature map covering the area of St. Arnaud Snow cover investigation - see text and Figure 5(b).

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21-6-d



Figure 5 (b)

Colour composite print of part of scene 2282-21252 printed to emphasise the snow area. Printed as follows:

Band 4 positive printed through blue filter

Band 5 negative printed through red filter

Band 7 negative printed through green filter

This resulted in the snow appearing as a reddish colour.

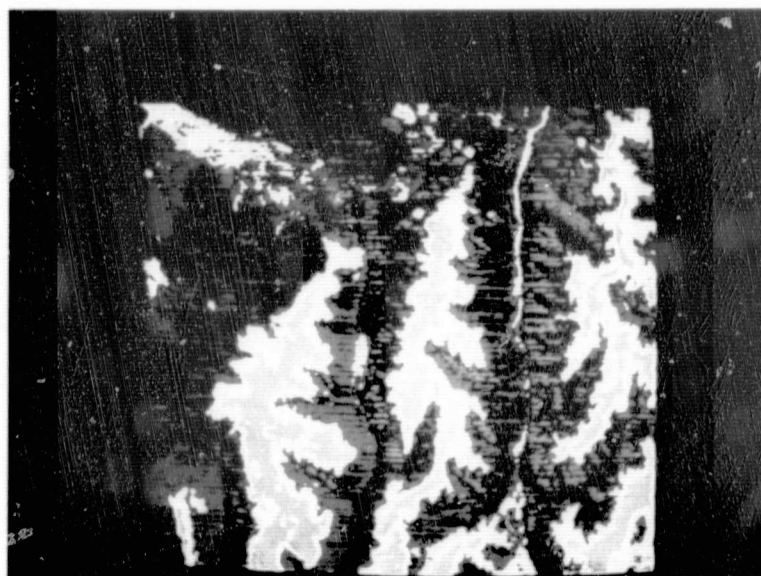


Figure 6

Colour isodensitometer coding of density levels from Band 4 positive transparency of the 2282-21252 scene recorded on 31 October 1975. The snow areas are suggested as occupying the yellow and purple region along the ridge tops. Differentiation between snow and high country tussock, exposed rock etc. will only be apparent by analysing this isodensitometric data in conjunction with MSS additive imagery similar to Figure 5(b).

21-6-f

PART VI

GEOGRAPHICAL APPLICATIONS IN LANDSAT MAPPING:

LANDUSE MAPPING AND ENVIRONMENTAL STUDIES

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INTRODUCTION

The Geography Department of the University of Auckland is analysing a range of LANDSAT colour composite imagery of New Zealand made available by PEL in July. The use of facilities for image interpretation at PEL remote sensing unit is gratefully acknowledged. Major interest is focussed upon -

1. landuse mapping,
2. vegetation classification,
3. pasture change and seasonal productivity,
4. hydrology,
5. geologic-geomorphic mapping, and
6. coastal processes.

All these investigations have important practical applications in the better understanding of the contemporary patterns of landuse and environment and the potential management of New Zealand's resources.

TECHNIQUES

Photographic Interpretation

Standard photo interpretation techniques were employed on selected LANDSAT 1:1,000,000 colour composites. In some cases single band LANDSAT images, also at a scale of 1:1,000,000, were analysed. Substage sampling was carried out using larger scale black-and-white aerial photographs and maps. Field surveys have been initiated for checking ground truth.

Enhancement Processes

Several enhancement techniques have been employed.

Optical enhancement -

A colour additive viewer was employed normally using Bands 4, 5 and 7 to produce false colour enhanced images.

Electronic enhancement -

Selected areas on various bands were density sliced and colour enhanced on a colour isodensitometer to provide additional detail for comparison with conventional photo mapping.

Computer analyses of some 6 mile x 4 mile areas were run by Dr M.J. McDonnell of PEL using the MSS CCTs to give line printout maps of patterns.

TOPIC 1

COMPARISON OF REGIONAL AND SEASONAL PATTERNS OF STREAM
SEDIMENT DISCHARGES FROM SKYLAB AND LANDSAT

An analysis was made of the information available from SKYLAB hand-held colour photographs and LANDSAT data of New Zealand. Photographic, optical, electronic, and digital processes were employed to extract information for mapping patterns of stream sediment discharges. Both types of satellite images shared several general properties of orbital imagery that made these superior to aircraft photographic products and additionally provided hitherto unavailable information.

The general properties of orbital imagery shared by both SKYLAB and LANDSAT that facilitated interpretation are the small scale, high altitude, and small angle of view providing broad synoptic views of large areas under uniform light conditions. Regional patterns of geology and landuse as well as hydrologic and ecological patterns are clearly portrayed and easily recognised. Such imagery is not distorted or otherwise modified as are aerial photo mosaics taken made from aircraft coverage flown at different times (seasonal and solar) under different lighting conditions and with varying angles of view. Tonal printing variations and the inevitable production distortions inherent in the large numbers of prints required for photo mosaics of large areas also add to the problems of aircraft coverage.

LANDSAT data has additional useful characteristics. It is multi-band and multifformat and therefore can be used to produce single narrow-band black and white photographs, or multiband false-colour composites. Computercompatible tapes (CCT) are also available for digital processing. An added advantage of LANDSAT over SKYLAB imagery was the ability to carry out digital analyses of small sample areas (6 miles x 4 miles).

The following interpretation techniques were employed on SKYLAB colour photographs and LANDSAT imagery:

1. Photo interpretation using tonal contrasts to map patterns.
2. Electronic processing using a colour isodensitometer:
 - (a) density slicing
 - (b) colour enhancement of different densities
 - (c) selective enlargement and subsequent density slicing and colour enhancement.

The colour isodensitometer studies provided a much greater range of gradations in sediment densities than was possible from conventional photo interpretation. Apart from the greater exactness of pattern

boundaries there was usually a three to four-fold increase in detail of subtle sediment density variations with the isodensitometer studies. Multispectral LANDSAT images, scanned optically on a colour additive viewer, provided an additional source of information.

The results from analyses of a selected SKYLAB and LANDSAT images of New Zealand were presented at the 1976 N.Z. Ecological Conference in Auckland on 24 August, 1976 and will be published in the PROCEEDINGS of the N.Z. Ecological Society. Therefore only a general summary of results follows.

Both the conventional colour photographs from SKYLAB as well as the LANDSAT MSS data - in both photographic and magnetic tape formats - provide useful information about regional and seasonal patterns of stream sediment discharges along New Zealand coasts.

The large area synoptic views from both SKYLAB and LANDSAT are superior to aircraft photographs and photo-mosaics. They provide a new source of previously unavailable imagery of large areas.

The multiband, multifORMAT LANDSAT MSS data aids interpretation by providing both qualitative and quantitative information.

For water penetration the most suitable remote sensors are those with wavelengths corresponding to green visible light (500-600 μm). Both the SKYLAB colour photographs and the LANDSAT Band 4 images were good for

1. interpreting maximum water depth penetration,
2. recording variations in water properties such as suspended organic or inorganic sediments, and
3. showing shallow water depths.

Studies of sediment patterns on both the west and east coasts of U.S.A. and in Alaska have shown a linear relationship between suspended sediments and LANDSAT radiance values. Limited comparisons carried out to date suggest the same relationship exists in New Zealand. The green visible band (500-600 μm) is the most useful for sediment studies but Band 7 (800-1100 μm) provides a valuable adjunct because of the sharp discrimination between the land-water interface. Additionally Band 7 provides greater information about river catchment properties.

Photographic, optical, electronic and digital processing of orbital data can provide much information about sediment patterns. Such information has potential geomorphological, engineering, ecological, and planning applications.

TOPIC 2

ANALYSIS OF SOUTH ISLAND COASTAL SEDIMENT PATTERNS
FROM LANDSAT DATAINTRODUCTION

The aim of this research is to attempt to analyse suspended coastal sediment patterns, both seasonally and regionally, through the use of synoptic and repetitive imagery from LANDSAT. Initially the research will be restricted to the mapping of sediment patterns followed by more detailed analysis of distribution and transport patterns of the sediment to allow greater understanding of the seasonal variation in sediment supply, current influence and coastal deposition of sediment.

Due to the absence of complete regional or seasonal coverage of LANDSAT imagery of the New Zealand coastline, investigation to date has been of a preliminary nature only. Nevertheless the study has allowed the development of some analytical techniques and also the formulation of some general conclusions which will be amplified through later research. These are:

1. Seasonal fluctuations in the amount of sediment can be easily observed.
2. The source and dispersal patterns of individual discharge plumes can be observed.
3. The pattern of sediment movement changes seasonally with a change in current patterns.
4. The area of active movement of suspended sediment extends offshore to a previously unanticipated distance.

METHODS

The analysis to date has been concentrated on the sediment patterns along the east coast of the South Island. LANDSAT images E-2192-21265-4 and E-2282-21254-4 have been used as these provide nearly cloud free conditions and easily analysed sediment patterns. After the initial photo interpretation from LANDSAT imagery information was extracted from the Band 4 through the use of a colour isodensitometer.

When a satisfactory image was produced with at least five

colour classes a slide was made of it. This was then used to map the sediment pattern by projecting it and delineating the colour classes (Figure 1). This method of mapping has certain limitations: the primary one is obtaining a stable image on the colour isodensitometer screen to be photographed. Certain colour combinations also resulted in better images being copied. Therefore, where possible only colours of white, yellow, two levels cyan and black were used for obtaining images for photocopying and subsequent mapping.

The sediment patterns in Pegasus Bay, north of Banks Peninsula were closely analysed and comparisons were made between the patterns observed on the two images, E-2282-2164-4 and E-2192-2165-4.

RESULTS

The Pegasus Bay coastline is an actively prograding plain. Studies of the area by geomorphologists indicate that the major sediment sources are the rivers of the area, notably the Waimakariri River (Figure 1). Much of the sediment is sand and grades of fine sediment which allows for easy suspension and wide dispersal by coastal currents. The major currents in the area are (1) those produced by the northward-flowing Southland Current, and (2) a near-shore, southward-moving eddy of this current which is the result of current bifurcation off the Kaikoura Coast (Figure 1).

Studies of the beach processes over a number of years by geomorphologists have resulted in some understanding of the influence the southward-moving, nearshore current has on sediment dispersal in the area. It has been shown that there is a strong preferential movement of sediment southward which has resulted in the formation of spits near the river mouths. Yet the annual net deposition in the area, while significant, indicates that much of the sediment is moved offshore and the distribution of this sediment is little understood.

Analysis of the LANDSAT images adds further information about the distribution and movement of the sediment. The pattern of sediment, which can be easily observed on both images, shows the expected pattern of current influenced sediment flow. The south-flowing, near-shore current results in a marked discontinuity in the gradation of sediment concentration with increasing distance from the coast. The colour isodensitometer image shows this particularly well (Figure 1) and suggests that while the current is certainly significant the main influence is about 1 km off-shore at the Waimakariri mouth. This is further shown by the near-shore sediments which do not exhibit any marked southward movement.

Plumes of high concentration of sediment extend both north and south from such major sources as the Waimakariri River. This may indicate that the northward movement of sediment, while not the preferential direction as shown by long term studies, is neither insignificant in amount nor unusual in occurrence as it is present in both images taken several months apart.

The two images give a marked contrast in the amount of sediment distributed in the Bay. This is the result of variation in river discharge. E-2282-2154-4 is at a period of relatively low flow while E-2192-21265-4 shows the sediment pattern under high discharge conditions after heavy rain. The latter image shows very high concentrations of sediment in the near-shore region and also suggests a northward drift of sediment in this zone which may be the result of weather conditions.

North of Pegasus Bay the sediment shows a strong movement to the north. The coastal currents appear to have a major influence on this pattern which continues along the entire Kaikoura Coast. Preliminary analysis of imagery of the Cook Strait area (E-2282-21191-4) shows that this strong movement results in sediments drifting across the Strait to join northward-moving patterns from North Island sources. This pattern is shown during a period of generally relatively low river discharge and thus implies that a much more definite pattern will result when there is more sediment. Further study as imagery becomes available will indicate the influence of tidal currents, weather conditions and seasonal variations on this pattern of sediment drift.

Thus this preliminary analysis allows the formation of several tentative conclusions of importance in understanding the sediment patterns of the area:

1. There is a movement of sediment southwards in Pegasus Bay by a near-shore current. The main zone of activity of this current is further offshore than expected prior to analysis of LANDSAT imagery.
2. Northward drift of sediment in the near-shore region of Pegasus Bay is neither unusual nor insignificant and may be the result of frequently occurring local weather conditions.
3. Northward movement of sediment occurs strongly along the Kaikoura Coast and appears to continue across Cook Strait to combine with sediments of North Island sources.

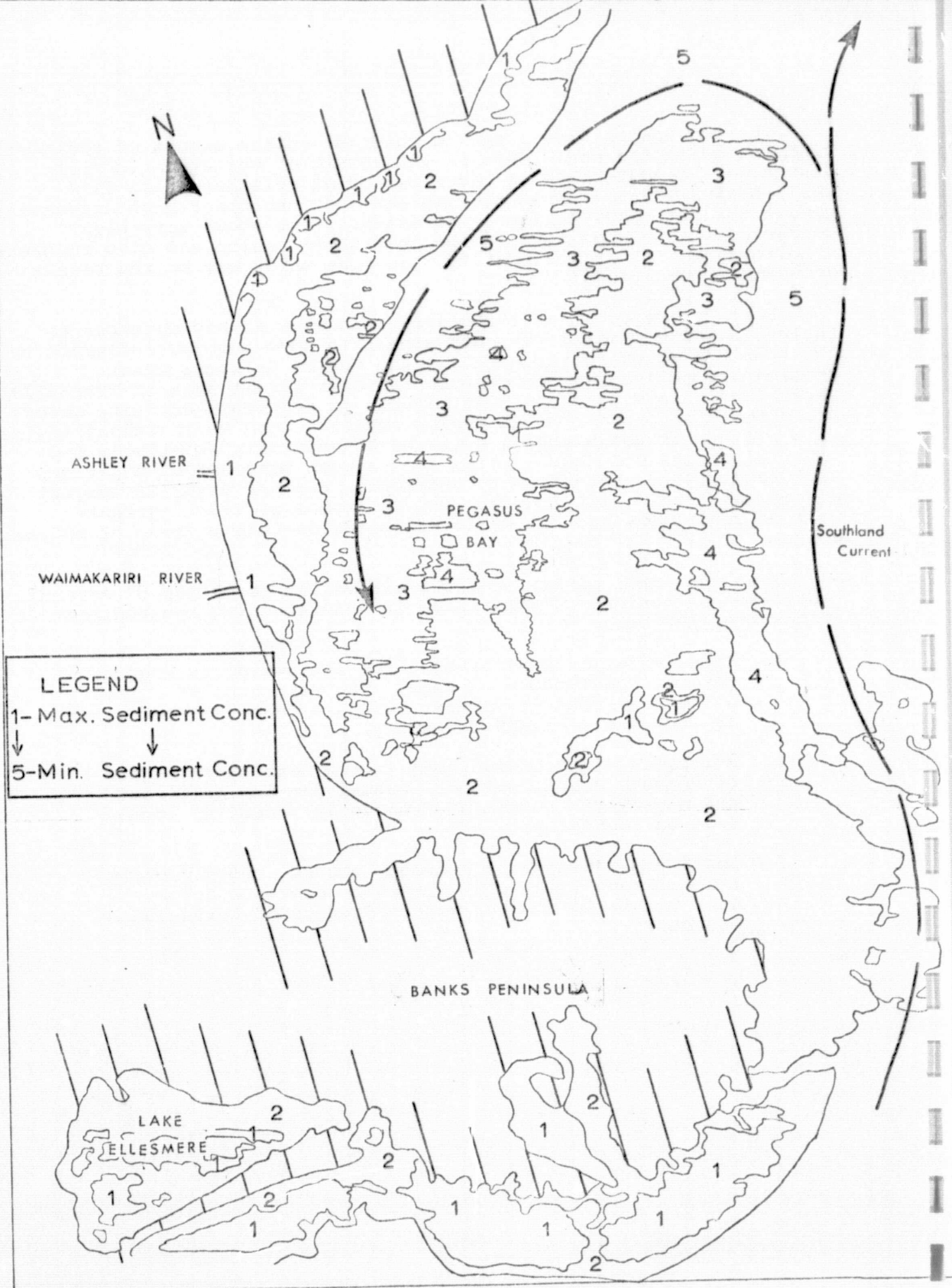


Figure 1 Sediment patterns drawn from colour isodensitometer image.

TOPIC 3

APPLICATIONS OF LANDSAT IMAGERY FOR MAPPING REGIONAL
GEOLOGY: A PRELIMINARY REPORT

The New Zealand Geological Survey has already demonstrated, in the June 1976 PEL Quarterly Report, that LANDSAT imagery is useful for mapping lineaments and for recognising broad morphological differences. They also stressed -

1. that snow cover and vegetation hindered mapping, and
2. that progress is likely to be slow and heavily reliant upon field work.

The Department of Geography at the University of Auckland have also begun lineament mapping of Marlborough region since receiving LANDSAT imagery in July. Similar mapping is being carried out in the Rotorua-Taupo region to test the technique in areas of different lithology, tectonics and vulcanism.

MARLBOROUGH REGION

Although a report of faulting and lineament mapping in this area from a LANDSAT image (E-2282-21252-4,7) using a colour additive viewer has already appeared, a more complete picture of the faults and lineaments in this area, using LANDSAT imagery can still be done.

Comparison of Band 7 positive black-and-white prints (1:1,000,000) of different times of the year has shown that this technique contributes additional information to that obtained from using a single two-band composite. Numerous overseas studies have shown that analysis of multidate imagery greatly facilitates mapping. While the seasonal differences in New Zealand are not as dramatic as in many of the overseas studies, subtlety of features does vary with seasons. Vegetation, soil moisture, regolith characteristics, and rock properties both individually and collectively when viewed multi-spectrally and sequentially provide useful information about lineaments.

In the current investigations, results have been encouraging. Although cloud and snow cover hinder analysis for broad morphological patterns, snow cover facilitates mapping if multispectral and multidate (sequential) analyses are carried out. Differences in vegetation cover can be very useful in delimiting subtle lineaments which often are continuous with known faults and lineaments.

ROTORUA - TAUPO REGION

Lineament mapping in this region has been confined to colour isodensitometer analysis of a Band 7 image (E-2334-21123). This has been compared with a black-and-white print of the same region. Patterns and lineaments have been enhanced by the use of the colour isodensitometer. Results to date have so far revealed many unknown lineaments in areas with a thick covering of volcanic ash. Many of these lineaments are continuous with known faults. Mapping and field checking are in progress.

TOPIC 4

COASTAL GEOMORPHOLOGY

Extensive areas of coastal sand dunes are present along numerous parts of the New Zealand coast. Preliminary mapping of a large area of mobile sand dunes on the north head of Aotea Harbour and along the west coast has been initiated using a Band 7 image (E-2389-21170). A colour isodensitometer image, photographed and subsequently projected upon a topographical base map has been prepared. Ground truth is being gathered so that information from the imagery can be correlated to the ground conditions. Patterns shown on the colour isodensitometer image suggest that dune and interdune patterns not visible on the LANDSAT image are portrayed. During this analysis an area adjacent to the survey area of dune known to have been cleared by a local farmer prior to sowing to pasture was also readily visible on the isodensitometer images.

It is hoped to extend this method of analysis to other areas of sand dunes particularly those near Foxton and in the North Auckland peninsula. LANDSAT-I image (E-1648-21420) of the far Northland peninsula would be an excellent one for detailed testing of the usefulness of colour isodensitometer analysis of sand dune areas.

TOPIC 5

PRELIMINARY REPORT ON VEGETATION MAPPING FROM LANDSAT-1INTRODUCTION

One of the tasks of geographers is to describe and explain the spatial distribution of phenomena on the earth's surface. It follows that the arrangement of natural and cultural systems, their spatial interaction and the aggregate characteristics and patterns of man's activities are an essential element of this task. To collect data over such a wide range of human and natural phenomena has, in the past, proved difficult. LANDSAT data has proved to be an excellent base for mapping resource-related phenomena and many physical expressions of man's activities.

METHODS

Conventional photo interpretation methods (direct observation and the use of zoom lopes [hand magnifying lens]) were employed on the two LANDSAT-1 (E-1503-21421) colour composite photographic prints made available from PEL. The colour composites were formed as follows: Print One assigned Blue to Band 4, Green to Band 5, and Red to Band 7; Print Two assigned Blue to Band 5, Green to Band 6, and Red to Band 7. Both composite images were produced MSS 5 Yellow, 6 Red, 7 Blue, both at a scale of 1:1,000,000. Broad vegetational patterns were established from these prints. Eight colour patterns were identified and mapped from Print One (Figure 2). Familiarity with colour infrared signatures perhaps prejudiced our preference in mapping from this colour composite rather than from the less usual Band 5-6-7 combination.

Two enlargements of portions of Print One covering areas A and B on Figure 1 were used to produce a more accurate distribution of the tonal patterns obtained. These patterns were confirmed through image enhancement of Band 7 (E-1503-21421) on D.S.I.R.'s colour isodensitometer.

INTERPRETATIONS

Interpretation of these patterns relied upon the following assumptions:

1. Excluding the snow and cloud-covered eastern portions

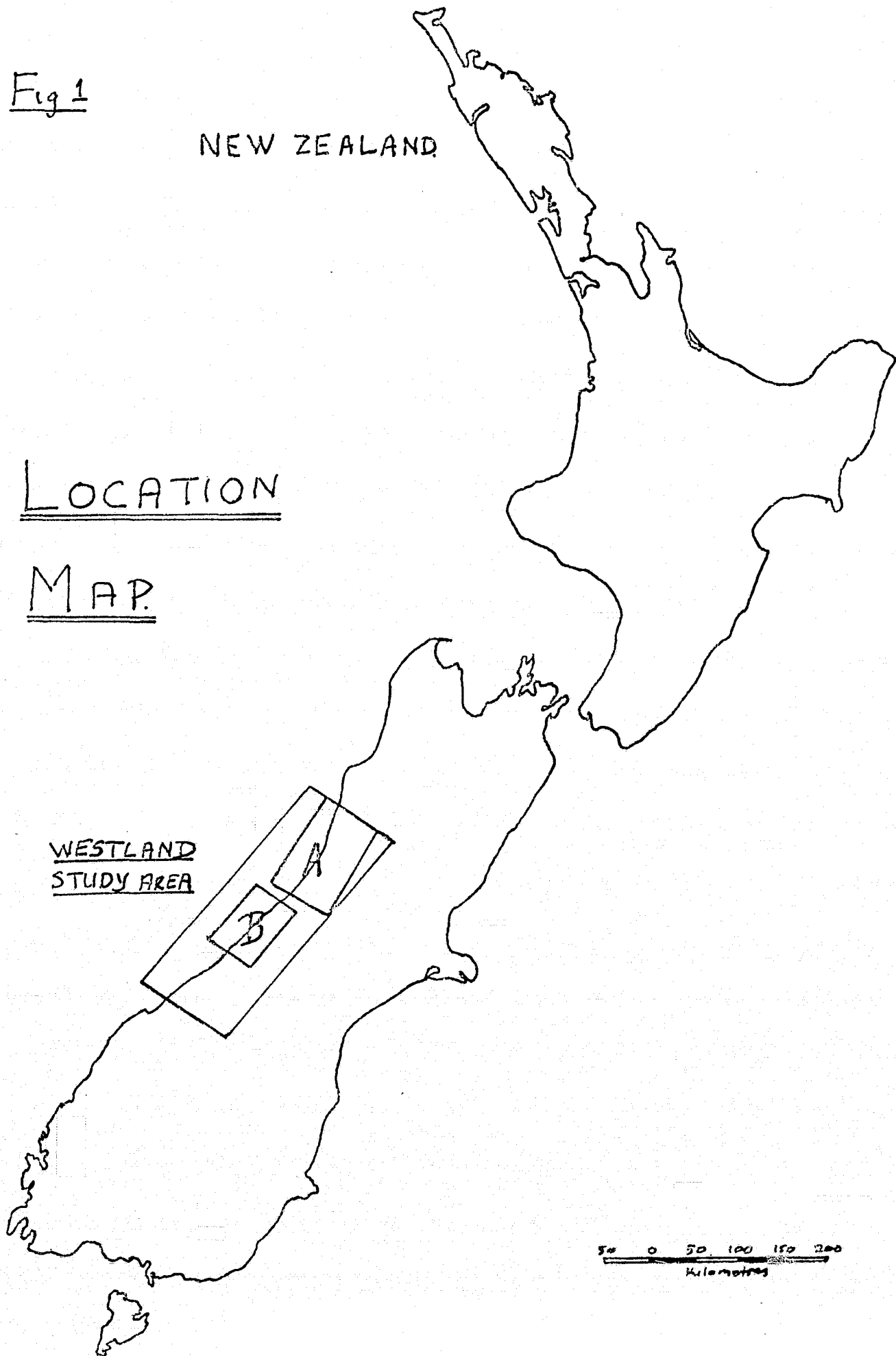
Fig 1

NEW ZEALAND

LOCATION

MAP.

WESTLAND
STUDY AREA



of the photographs, most of the area is vegetated and this vegetation is chiefly responsible for the spectral reflectances registered on the image.

2. As different vegetation types have different spectral characteristics then image chroma and hue infers different vegetation types and their distribution. Broad-leaf species with a larger percentage of the leaf composed of water filled spongy mesophyll will produce a stronger spectral signature (bright red) than the sclerophyllous podocarps (dark magenta). Earlier research using low altitude aerial photographs over (1) Pureora Forest, (2) central North Island, (3) Waitakere and Hunua Ranges near Auckland, and (4) Omaha and Waipoua in Northland, has confirmed this assumption. Using paired colour and colour infrared films with Kodak Wratten No. 12 filter, it was possible to identify species from the resulting mosaic of hues on the colour infrared prints. Enhancement of slight variations in red tones by the use of colour compensating filters such as Kodak CC30B and 89B made it easier to differentiate between the various gymnosperms present. Using colour and colour infrared aerial film Cochrane (1974) identified the following characteristics: (1) exotic conifers have a distinctive dark red hue, (2) broad leaf species a bright red hue, (3) podocarp a darker magenta hue, (4) kauri pink hue, (5) tree ferns a brilliant bright red hue, (6) mature tawa light blue hue and (7) dead trees dark blue hue. Pastures and scrub also have their own distinctive hues.
3. Positive identification of spectral signatures located in the area depended on substage sampling of the vegetation types by means of pan vertical aerial photography (scale 1:25,000), field observations and information in literature including vegetation maps, e.g. South Island Beech Resources Maps, West Coast.

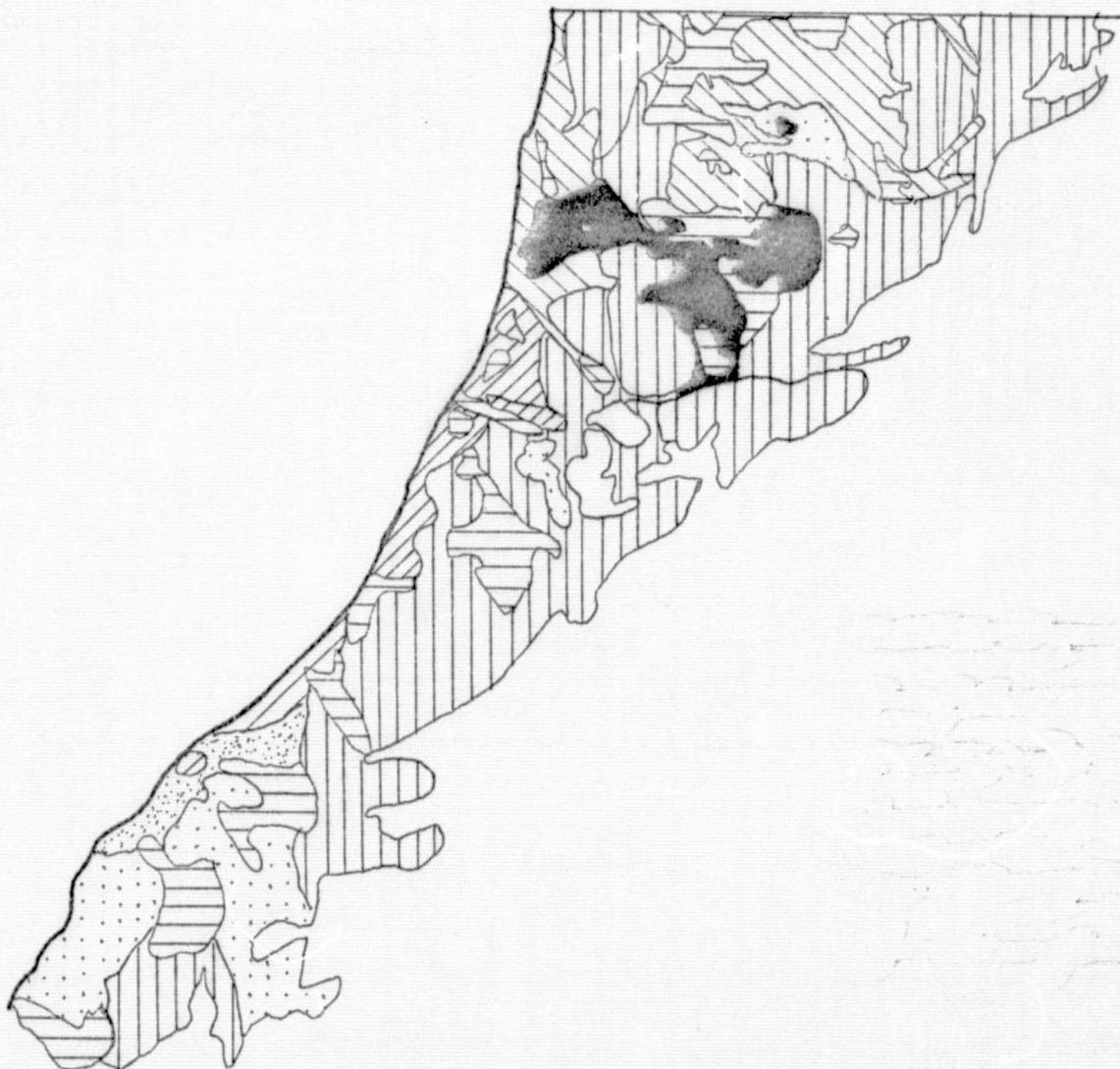
To date, four vegetation types have been positively identified on LANDSAT imagery for the Northern Sector (location A Fig. 1). Their distribution is recorded on Fig. 3. A full commentary on these and other types will be included with the completed vegetation maps in the next report.

Reference:

Cochrane, G. Ross. 1974. Remote sensing applications in New Zealand forest resource evaluation. Proceedings International Geographical Union Conference and 8th N.Z. Geography Conference: 227-233.

Fig 2

WESTLAND VEGETATION COLOUR PATTERNS

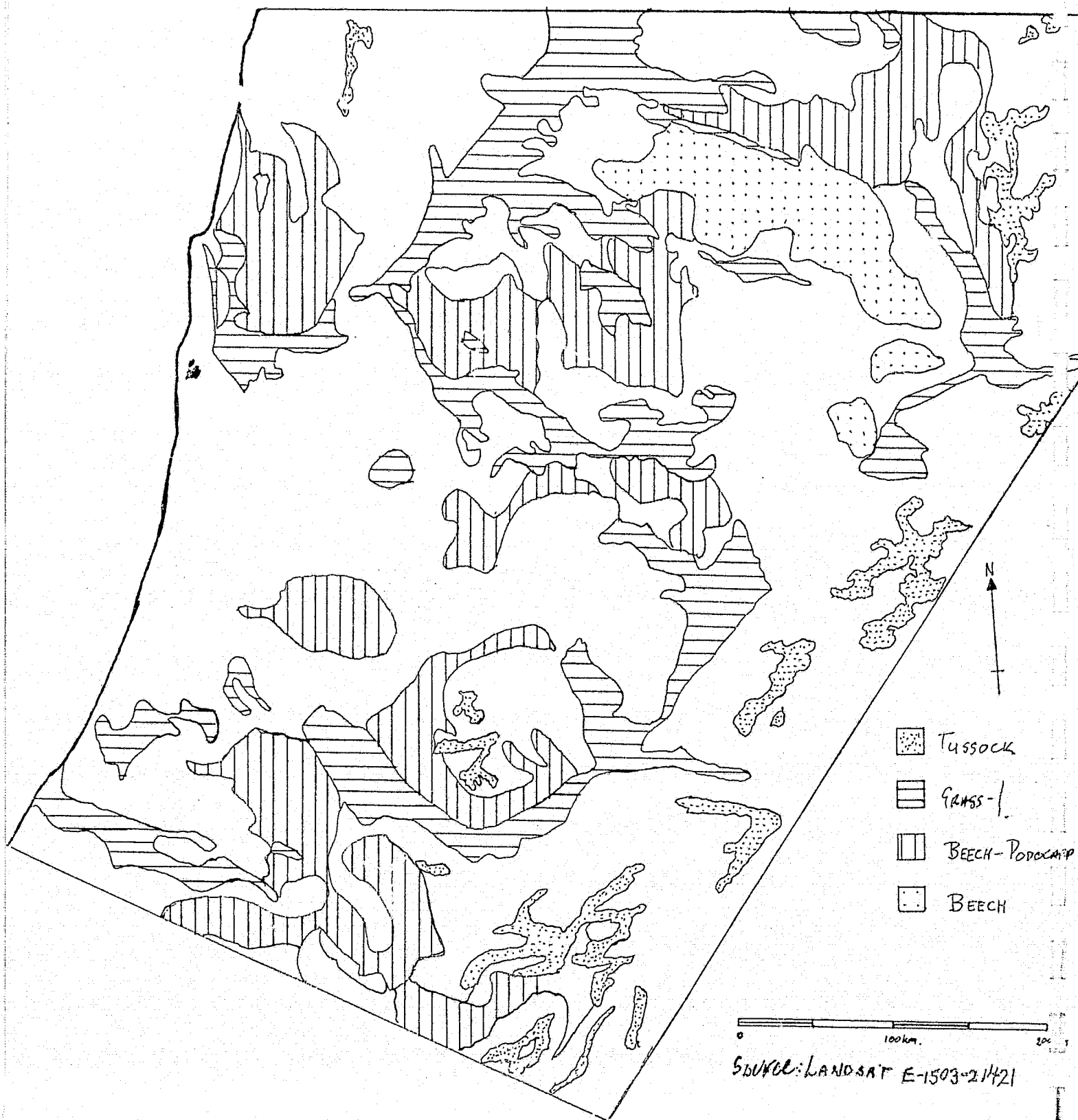


KILOMETRES.
0 8 16 32

Vegetation Patterns. Patterns were mapped from a colour composite of E-1503-21421-5,6 and 7 from Dec. 8, 1973. Documentation underway should reveal the vegetation responsible for these colour patterns.

Fig 3

WESTLAND VEGETATION MAP - NORTHERN SECTOR



TOPIC 6

PRELIMINARY NOTES ON LANDUSE MAPPING FROM LANDSAT-II -
ROTORUA-TAUPO-NAPIER REGION (E-2334-21123)

INTRODUCTION

An excellent LANDSAT-II colour composite (E-2334-21123-4,5,7) of the study area taken on 22 December, 1975 was made available by D.S.I.R. to the Geography Department of the University of Auckland in July. This image is virtually cloud free with only a very small area of cloud west of Lake Rotorua. The Rotorua-Taupo-Napier Region is an area of complex and varied geology, landforms, natural vegetation, exotic forests, and agricultural landuse (pastures, horticulture, arable agriculture). There are also urban settlements; areas of severe erosion; a snow covered mountain; lake, estuary and open ocean water bodies; areas of newly planted forest; cleared areas; older burned and newly burned areas. Almost all the distinctive landforms and land cover classes found in New Zealand are within the image coverage. The study area also serves to complement the Canterbury Plains Darfield test area on South Island.

TECHNIQUES

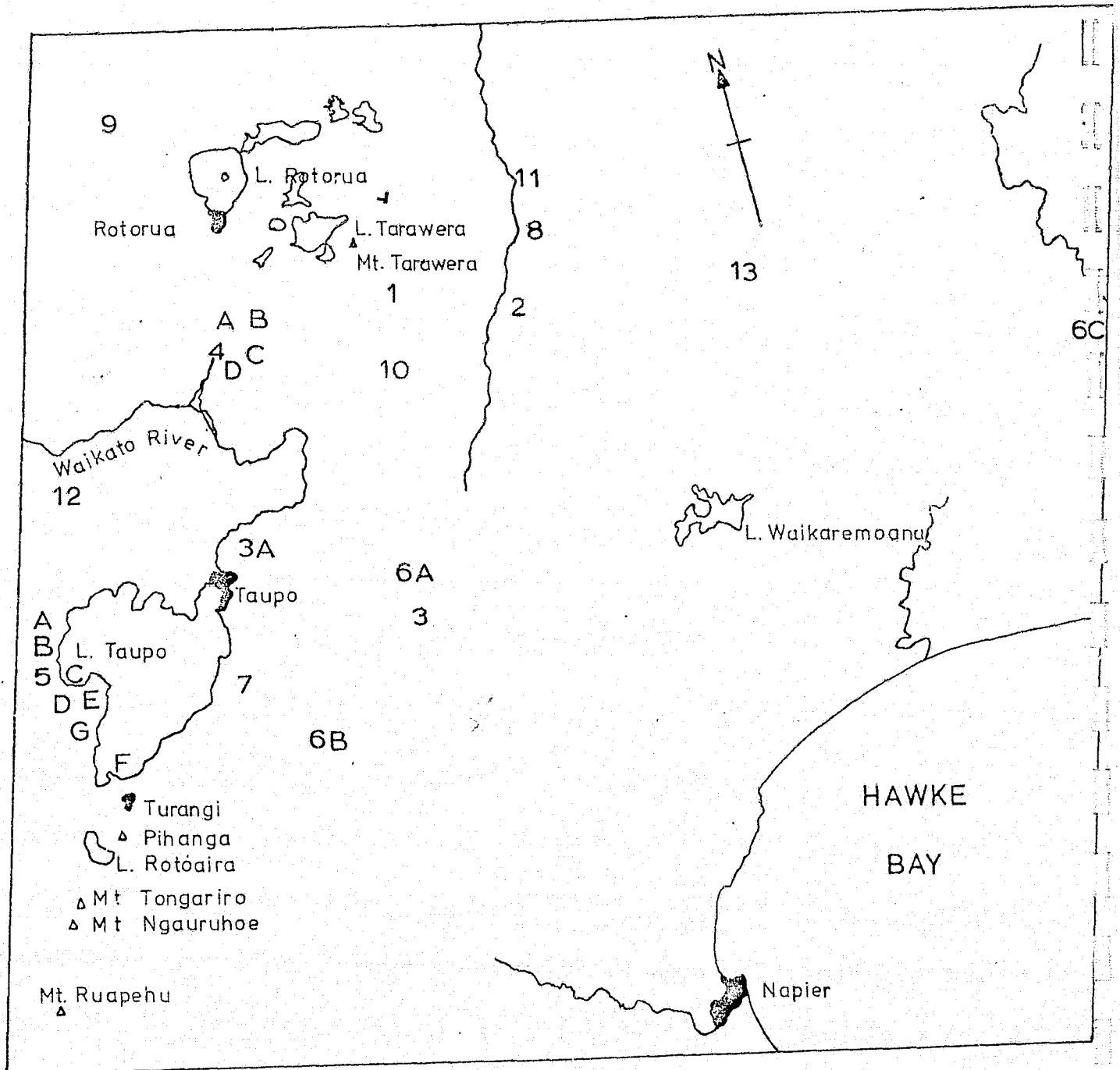
In this preliminary report the techniques employed were

1. conventional photo-interpretation from the 1:1,000,000 colour composite,
2. inspection of separate band positive transparencies, and
3. comparison with available maps and ground knowledge of the area.

The use of (a) single-band enlargements of specific areas, (b) a colour composite enlargement to the maximum possible scale (1:1,000,000), (c) a photowrite colour composite image, (d) line printout maps of sample areas derived from computer analyses of CCTs, (e) sequential coverage and other data modes, mensuration, and interpretation techniques should be very rewarding in this study area.

A sample of features shown on this image will be briefly discussed. The numbers on Figure 1, drawn at the same scale as the colour composite, correspond to the locations of features on the colour composite. This figure should be placed opposite for optimum

FIGURE 1: CENTRAL NORTH ISLAND-LOCATION OF STUDY AREA



Drawn from LANDSAT E-2334-21123
Scale 1:1,000,000

comparison with Figure 1 PART 1 of the this quarterly report.

RESULTS

Soils, Pastures and Crops

Rerewhakaaitu Basin

A line running NW/SE through the western side of Lake Rerewhakaaitu (1) separates two parts of the Rerewhakaaitu Basin by colour and density. The eastern half is much lighter in tone. Careful analysis of farm size and land utilisation shows that the tonal variation cannot be explained by agricultural practices and therefore it is suggested that the line marks the boundary of the 8 cm (approximately) isopach of 1886 Tarawera lapilli composed of black, gravelly, basaltic fragments. These soils have poor moisture retention and are very susceptible to drought after several days without rainfall. The December date suggests that the marked contrast in tone is closely related to differences in pasture conditions.

In the southern and south eastern parts of the Rerewhakaaitu Basin an area of smoother texture with darker tone can be identified. The area delineated reasonably defines a Lands and Survey Development Block. This is farmed on an extensive basis rather than subdivided into small farms as is the case for most of the Basin.

West of the NW/SE line there are 1886 Rotomahana mud soils which form grey, structureless, sandy loams with good soil moisture retention characteristics. Band 4 and 5 images show these patterns clearly suggesting it is a function of both soil reflectivity and soil moisture rather than entirely a major variation in pasture properties, particularly as the differences are not shown on Bands 6 and 7.

Galatea Basin

Light tones predominate through much of the Galatea Basin where drought prone pastures, formed on pumiceous soils derived from Kahoroa or Tarawera ash, are located. The lightest tone areas correspond to broad, poorly watered interfluvies. Near stream courses on soils formed from recent alluvium soil moisture content is higher and pastures do not dry out so readily. These areas show clearly with a brighter red signature.

The pin points of dark red which occur within the Galatea Basin and also to the east of Lake Rerewhakaaitu are 2.5 to 5 hectare paddocks of lucerne (alfalfa) that have retained their dense, green, relatively high (20-30 cm), ground cover because their roots penetrate the surface soil to moisture reserves below. Lucerne has a distinctive bright red signature in contrast to the pale tones of drought-stressed,

shallow-rooted, pasture grasses. Sequential imagery of this area would be valuable in tracing the progression of drought-affected areas. Over a period of years a record could be built up to show drought prone areas and additionally to trace changes in crop patterns such as lucerne for supplementary feeding.

The southern Kokomoko Development Block (3) shows an intermediate stage in lucerne development whilst the Wairakei Research Station shows the normal situation for this area (3a).

Land Utilisation

There appear to be significant textural differences in pastures and therefore tonal contrasts on the LANDSAT imagery enable separation of land utilisation types - particularly dairying from sheep and cattle rearing. The former are characterised by smaller paddocks (fields) and a more intensive grazing management resulting in a shorter grass sward. Such differences can be postulated at the 1:1,000,000 scale of the colour composite but could be determined more easily at larger scales. Compare, for example, the following areas:

1. The dairy area around Reporoa (4a) with the sheep and cattle area to the east (4b).
2. The dairy area in the north of Waikite Valley (4c) with the sheep farming area to the south at 4d.
3. Reporoa dairying with extensive pastoral farming at Te Hapua (5e) and Hauhungaroa IC Development Blocks (5g) on the western shores of Lake Taupo.

Western Taupo, Kuratau - Kotuka

Distinct tonal signatures are evident from various types of land use.

Burnt-over and subsequently cultivated land (5b) being prepared for afforestation appears bright, light blue. This area near Moutere is also apparent as a distinctive light tone on each of Bands 4, 5, 6 and 7 but is most conspicuous on Bands 4 and 5. Many other areas of cleared land with bare soil prominent show elsewhere especially in the Kaingaroa Forest area where light blues of clear felled forest blocks (6a) contrast markedly with the red tones of forest areas.

The extent of arable land (blue tones) to pasture land (pink tones) can be measured in farming areas such as at Waikite (4c, 4d), east of Lake Taupo on newly developed farmland (6b), and on the central eastern boundary of the image (6c). The dark tone of the area of scrub land at Hauhungaroa ID3B Inc. (5d) and larger areas east of Lake Taupo (7) results from the dull coloured, sclerophyllous, small-leaved vegetation with low infrared reflectance. Information has been restructured recently and development to pasture will take

place in the next few years. Sequential imagery would be able to monitor these sorts of change.

The area with a greenish signature at Waipapa (5a) is part of the Lake Taupo Reserves Scheme. This stream and bush area is alienated from production as a soil conservation measure.

The bush reserve on Karangahape Point (5c) is characteristic of indigenous forest tones and is in marked contrast to the pink tones of pastures in the adjacent Te Hapua Development Block (5e). A range of subtle tonal changes in areas of indigenous forests appears to be consistent with species changes, e.g. on the Mamaku Plateau (9) where changes between large rimu-rata and logged tawa-kamahi are paralleled by tonal contrast.

The dark charcoal blue tones of very recently fired areas (8) is shown clearly just north of the Galatea Basin. This area was burned barely three weeks before this image was taken.

Bare rock areas such at Mt Ruapehu and Tarawera have a very distinctive blue tone that is not readily confused with arable or bare earth areas.

The swamp area at Stump Bay (5f) in the extreme southern end of Lake Taupo is not as clearly seen on the colour composite as on Bands 6 and 7.

A broad band (possibly of weeds or of sediments from land development) in Lake Taupo is not discernable on the colour composite image but is easily seen on Band 4, is visible on Band 5 and is just discernable on Band 6.

Exotic Species in Kaingaroa Forest

Even at the 1:1,000,000 scale and with a photographic colour composite it is possible to identify areas of different species and different age stands of exotic conifers. See for example the area marked 10. In this locality an area of almost black tone (10) is old Pinus nigra. Nearby a small plot of slightly lighter tone may be identified. This is a plot of old P. ponderosa. The extensive areas immediately north and east of these stands, coloured a lighter tone of red (dark carrot-red) are thinned Ps. menziesii (11). The plots further to the west and of a deeper red tone are P. radiata. There may be some soil differences here also as these patterns show in the Band 4 image.

There is a very obvious potential application for the development of thematic maps, synoptic charts and computer maps of forest holdings, workings and changes because of the large size of the units and their distinctive tonal contrasts (radiances).

Geological Information

Although all covered in forest the very obvious textural contrast associated with the Cretaceous, Jurassic and Triassic greywackes of the main axial ranges (Kaweka, Ahimanawa, Huiarau and Ikawhenua Ranges) and the Miocene calcareous sandstones and siltstones of the Pa' kiri and Ngamoto Ranges in the Lake Waikeremoana area illustrate significant differences in lithology and type and intensity of dissection of these areas. These geological differences are reinforced by the vegetation cover with podocarps, particular rimu dominant communities being present on the greywackes, and beech forest on the sandstones and siltstones. Both tone and texture differences are very apparent. Where Miocene rocks are present in the greywacke ranges the beeches become important again.

TOPIC 7

VEGETATION COVER/LAND CAPABILITY MAPPING FROM
LANDSAT-II IMAGERY OF EAST TAUPU

INTRODUCTION

In order to fulfil other research needs an up-to-date base map of land cover was required for the Hiremaiaia River basin and environs in East Taupo. The area under study is shown in Figure 1.

Published sources of data on landform and vegetation cover available for the area include:

1. N.Z.M.S. Topographical maps

Series 18, sheet 8, Taupo at a scale of 1:250,000 shows very little detail even as to generalised contours or land cover. The latest edition of this map was published in 1964.

Series 1, sheet N103, Rangitiki at a scale of 1:63360 provides greater detail and was published in 1969.

2. Aerial Photographs

The most recent air photographs were run in 1965-66. Much change has taken place in the vegetation cover since this time and therefore the photos cannot be regarded as a reliable base. Other air photograph runs at larger scales of 1:15840 and 1:23760 were flown in 1945 and 1952 respectively and therefore exhibit little relevance to details of the current vegetation cover.

3. LANDSAT-II Photograph E-2334-21123

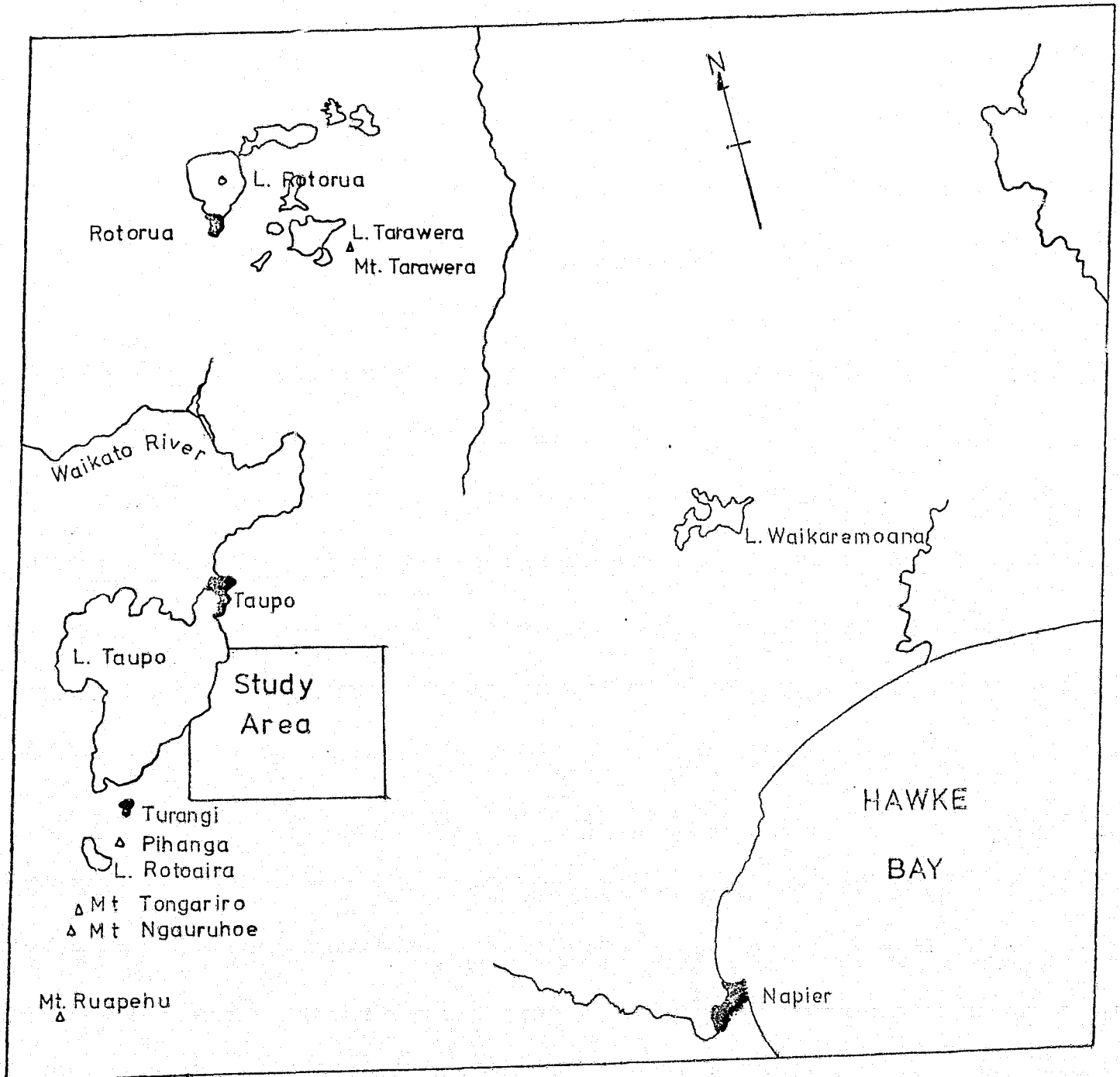
Taken in December 1975 this provides the most recent survey of the region. However, the area under study occupies a small part of the print (Figure 1 and Figure 2 [which is Figure 1, Part I]).

The remainder of this report discusses the degree of usefulness that an enlargement of a Landsat-II photograph provides for vegetation mapping.

PROCEDURE

Band 7 (E-2334-21123) gave the best visual representation of landform and, as this band records infrared radiance, variation in vegetation cover. Using the P.E.L. Remote Sensing Laboratory's colour isodensitometer Band 7 (E-2334-21123) was enlarged and enhanced

FIGURE 1: CENTRAL NORTH ISLAND-LOCATION OF STUDY AREA



Drawn from LANDSAT E-2334-21123
Scale 1:1,000,000

on a colour television screen and photographed onto colour slide film (Figure 3). All channels except blue were used.

The colour slide produced was then projected onto a screen at a scale of approximately 1:57,100. Because of the curvature of the television screen the scale is not consistent over the entire slide. The scale of 1:57,100 was calculated by comparing the distance between Te Kohaiakahu Point and Toki Point (Figures 4 & 5) with the N.Z.M.S. 1, N103 topographic map at 1:63,360.

A map was drawn off this projection (Figure 4). The original photo was simplified on this map into the six categories listed below:

<u>Class 1</u>	corresponds to yellow areas from the colour isodensitometer viewer, channels 1-4.
<u>Class 2</u>	corresponds to light cyan, that is channels 5 and 6.
<u>Class 3</u>	corresponds to dark cyan, channels 7 and 8.
<u>Class 4</u>	corresponds to green - mostly from channels 9 and 10.
<u>Class 5</u>	corresponds to orange and red, channels 13 to 20.
<u>Class 6</u>	corresponds to magenta and violet, channels 21 to 28.

In August 1976 field observations were made at various points within the lower Hinemaiaia River basin and on the surrounding plateau. Several observations had to be made from some distance due to the inaccessible and impenetrable nature of the basin.

RESULTS

Landcover corresponding to classes on the base map from LANDSAT-II data

Class 1. This corresponds to pasture or cropped land, for example as found at Collins' farm and Poronui station.

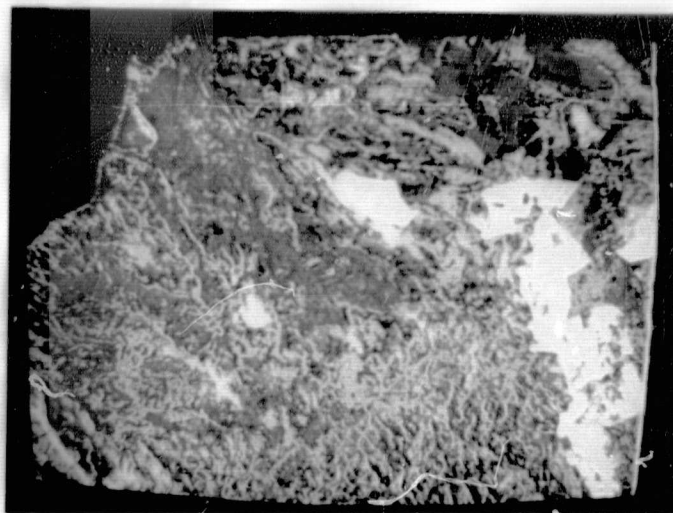
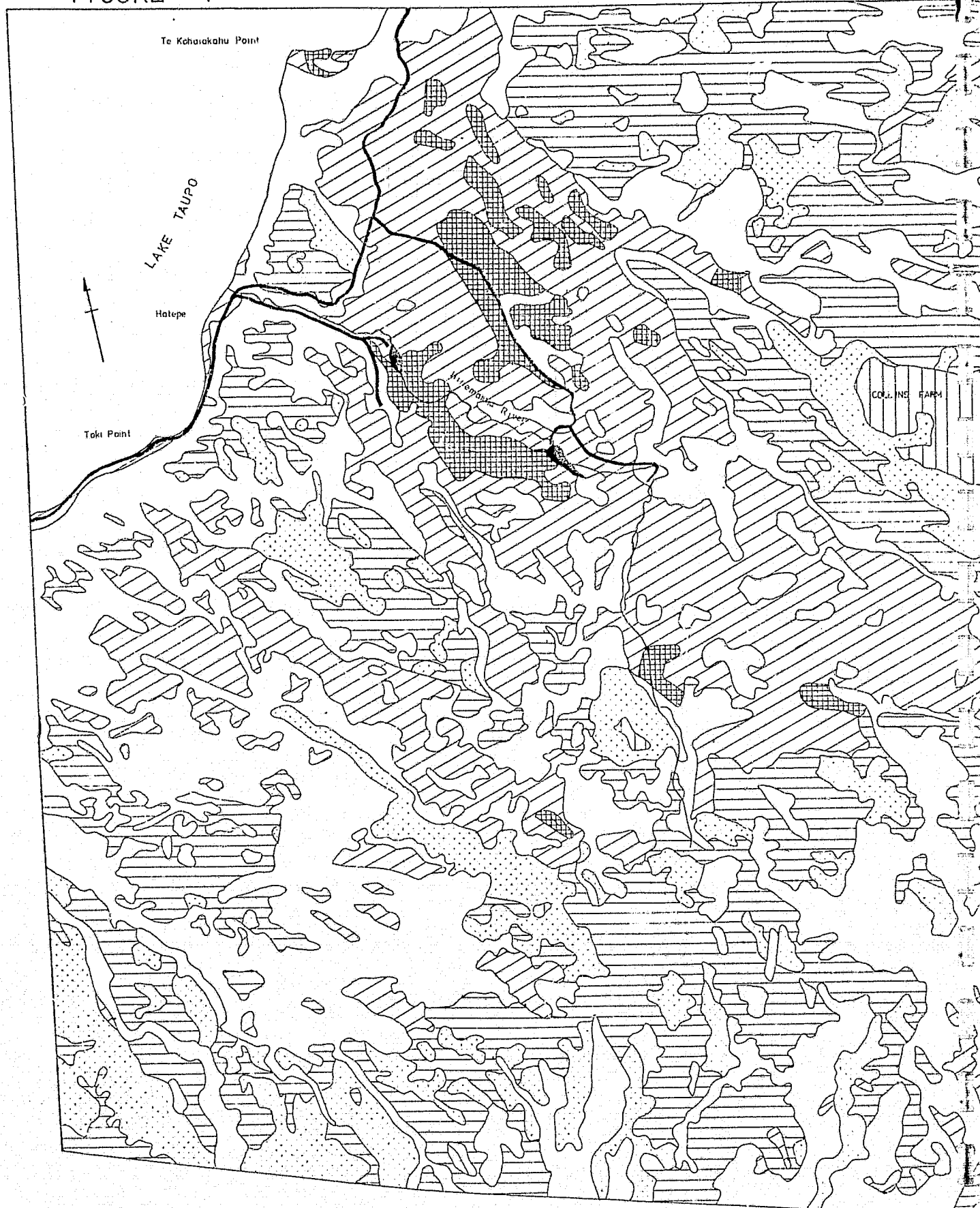


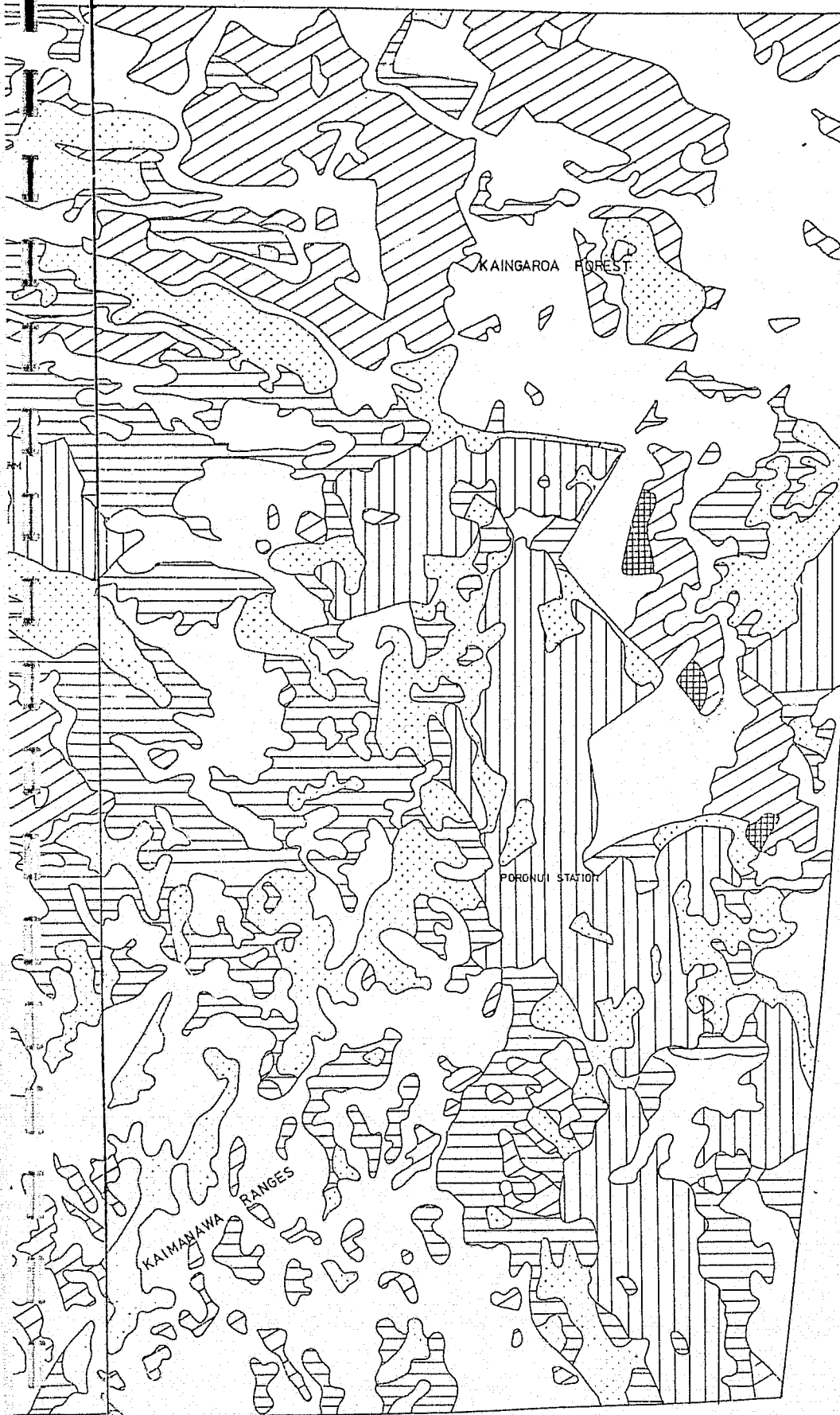
Figure 3

Colour-enhanced enlargement of Hinemaiaia Basin,
East Taupo from LANDSAT E-2334-21123-7 image.

FIGURE 4 Hinemaiaia River Basin and Environs simplified from Figure 3.



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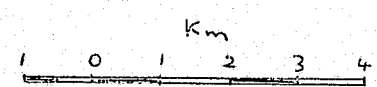


- 1 YELLOW
- 2 LIGHT CYAN
- 3 DARK CYAN
- 4 GREEN
- 5 RED
- 6 MAGENTA

ROADS

LAKES

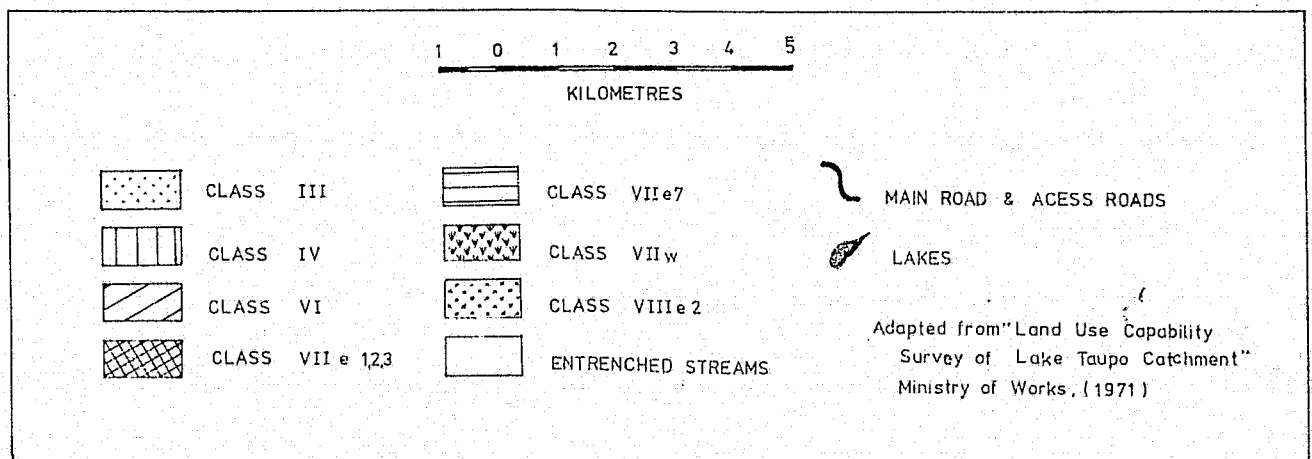
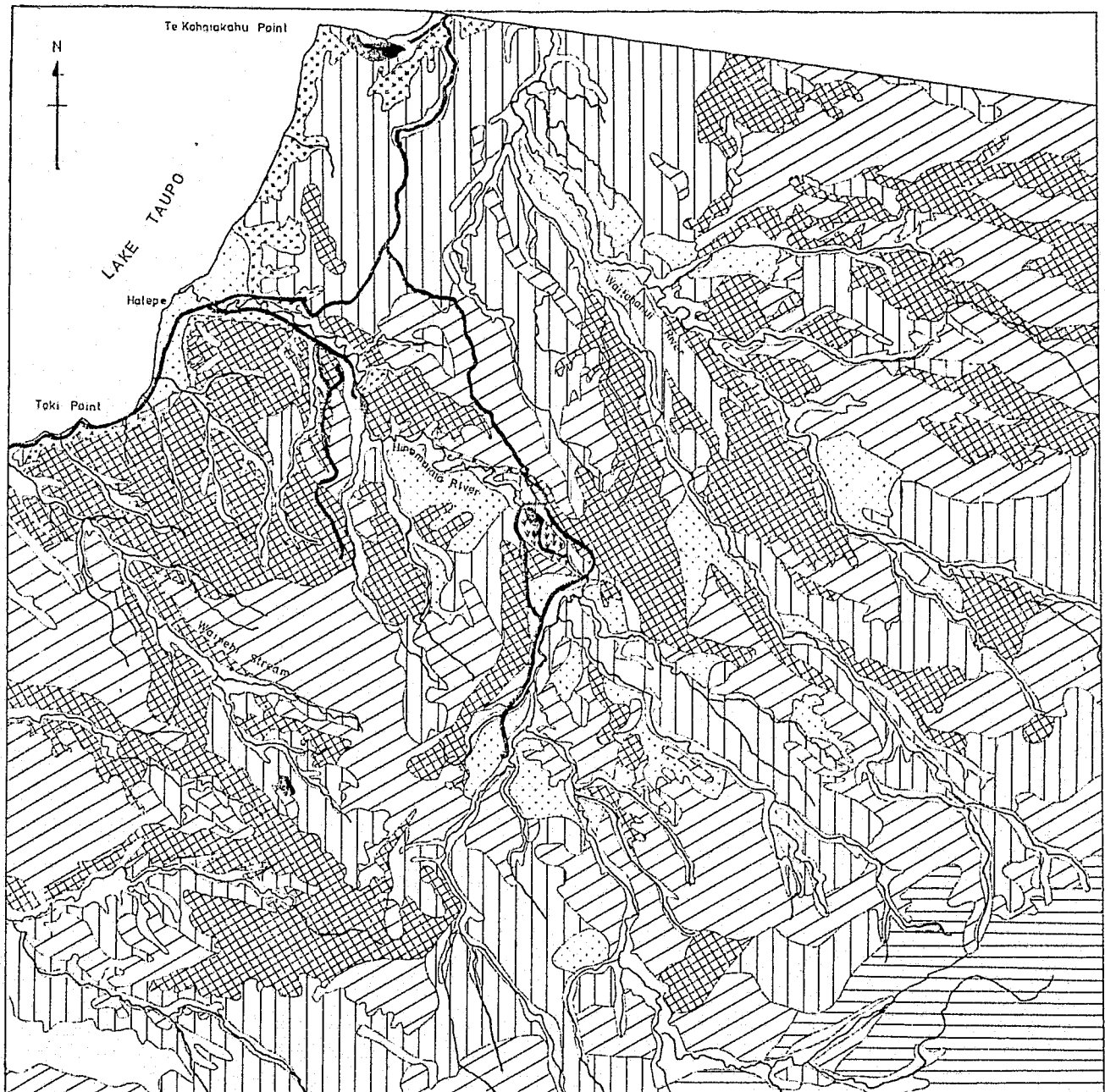
SCALE 1:114200 approx.



From Colour-enhanced LANDSAT-II Image
E-2334-21123

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FIGURE 5 Land Use Capability Map of Study Area.



Class 2. Areas in this category are covered by low shrub (mainly manuka, Leptospermum spp.) and/or tussock grasses. In some cases, if not all, this represents vegetation that has recolonised previously cleared areas. Patches of class 2 also occur in the Kaimanawa Ranges (Figure 4). Some of these peaks exceed 1200 m so the patches probably represent sub-alpine vegetation.

Class 3. This category seems to be intermediate between 2 and 4 being composed of low shrub species but being less dominated by manuka and containing a number of soft-leaved species, notably Hebe stricta.

Class 4 (a). These areas correspond to a cover of secondary bush with a variety of understory species, for example a large proportion of Hebe stricta, bracken (Pteridium esculentum) as well as toetoe (Cortadenia spp.) and New Zealand flax (Phormium tenax).

Class 4 (b). Included in this category is most of the Kaimanawa Range area (lower right hand corner of Figures 4 and 5) and is possible due to a predominance of broadleaved tree species such as Nothofagus. (Southern beech).

Class 5. More subtle differences in tone are recognisable within this class (Figure 3) but are difficult to delineate. The category represents dense scrub and exotic (pine) forests.

Class 5 (a). Bordering the lake from Hatepe to Toki Point and around Te Kohaiakahu Point is an area of tall (20-30 m) exotics (pines, poplars and eucalypts).

Class 5 (b). Exotic pine plantations show as solid red (that is no magenta associated with these areas) in the Waipahi River basin (Figure 5) and in the north-east of the map (the southern section of the Kaingaroa State Forest).

Class 5 (c). The main bulk of this category, on a plateau north of the Hinemaiaia River, represents dense almost pure stands of manuka mostly 5-6 m tall but individuals may reach 10 m in places. Various other shrubs, ferns, broom and bracken make up a very thick ground cover. Within this area gullies, most notably on the edges of steep-sided river valleys, may be covered by taller tree species notably, totara. Any difference in reflectance will not be recognised at this scale as the gullies may be only a few hundred metres long.

Class 6 is quite readily differentiated on the LANDSAT-II photo-enhancement but not so easily recognised in the field. However, there is a gradual change on the plateau area from the dark-coloured manuka to a greener heath and may be the reason for the difference observed in Figure 3. The general form of vegetation for this area is, however, the same as that of Class 5 (c).

CONCLUSIONS

Usefulness of LANDSAT-II imagery for large-scale vegetation mapping

Although in the particular area under consideration vegetation cover is relatively uniform, the colour enhancement of a LANDSAT-II image has provided a fairly detailed base map differentiating vegetation cover types. Even though species compositions change from one area to another along some physical gradient, such as soil type or altitude, tonal values from Band 7 as represented on the colour isodensitometer can be used to infer grass vegetation cover types in similar but different locations. It would be expected, therefore, that studies for other basins in the Taupo area from the same data would perhaps allow the same general vegetation categories to be mapped.

SUMMARY

Although it is difficult to plot positions on the map from the LANDSAT-II image as neither small rivers nor roads can be distinguished the map is quite accurate as a base map for field investigations.

Subsequent LANDSAT photographs obtained of the same area could be subjected to similar procedures and land use changes monitored at intervals. This is a feasible proposition for this area as it is rapidly undergoing afforestation in both the Kaingaroa Forest and the East Taupo State Forest of which the small area in the Waipehi basin is the northernmost extent.

Reference:

Ministry of Works 1971

Land Use Capability Survey of Lake
Taupo Catchment.
Water & Soil Div. M.O.W.
Palmerston North.